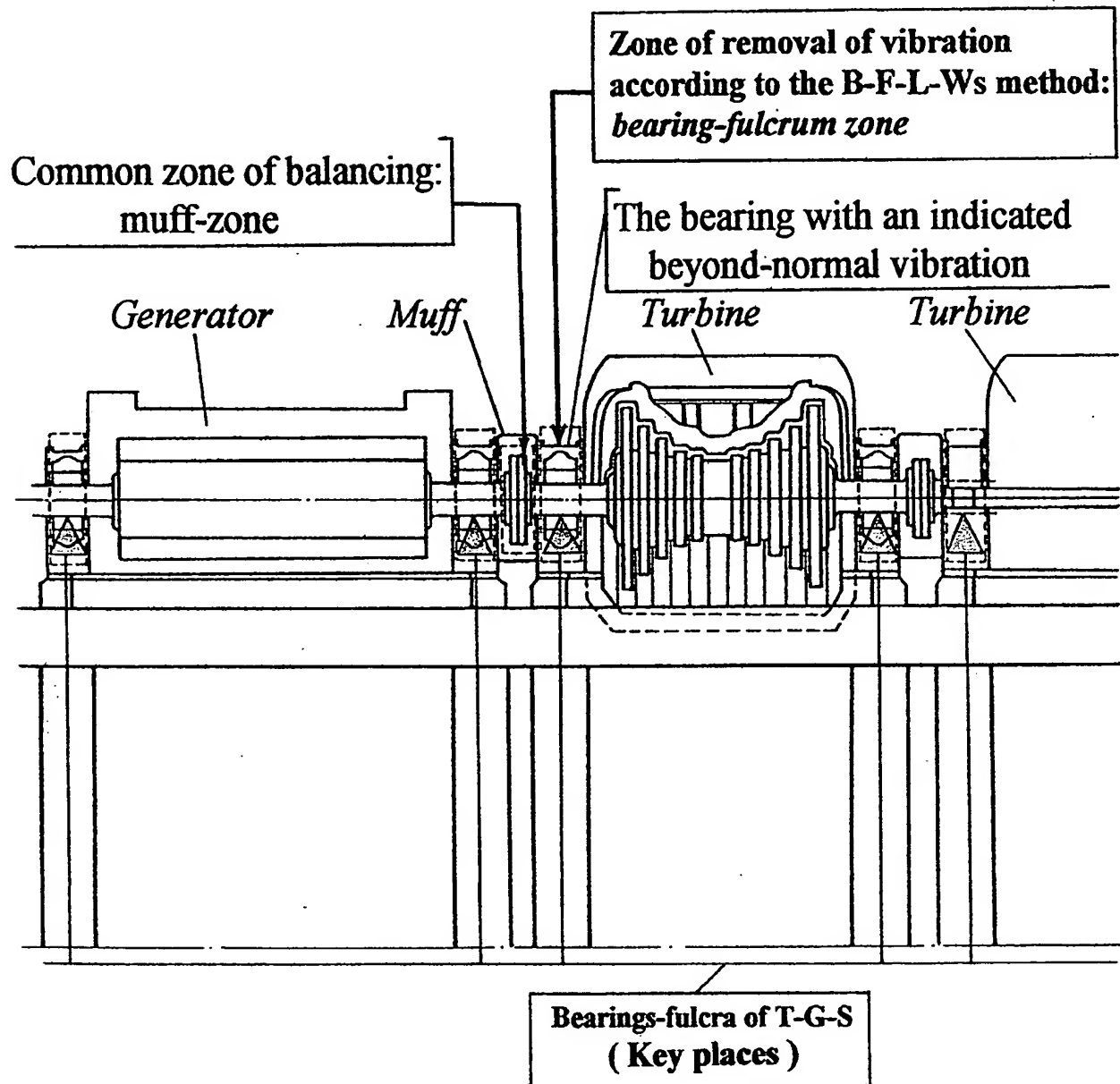
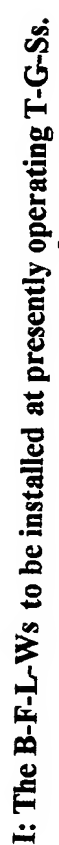


## Turbine Generator Vibration Damper System. Vladilen Safonov.



**Fig. 1 Zones for application of the process (the method of removal of beyond-normal vibrations at T-G-Ss without stopping their generating electricity / being in operation) - bearings-fulcra zones.**

1



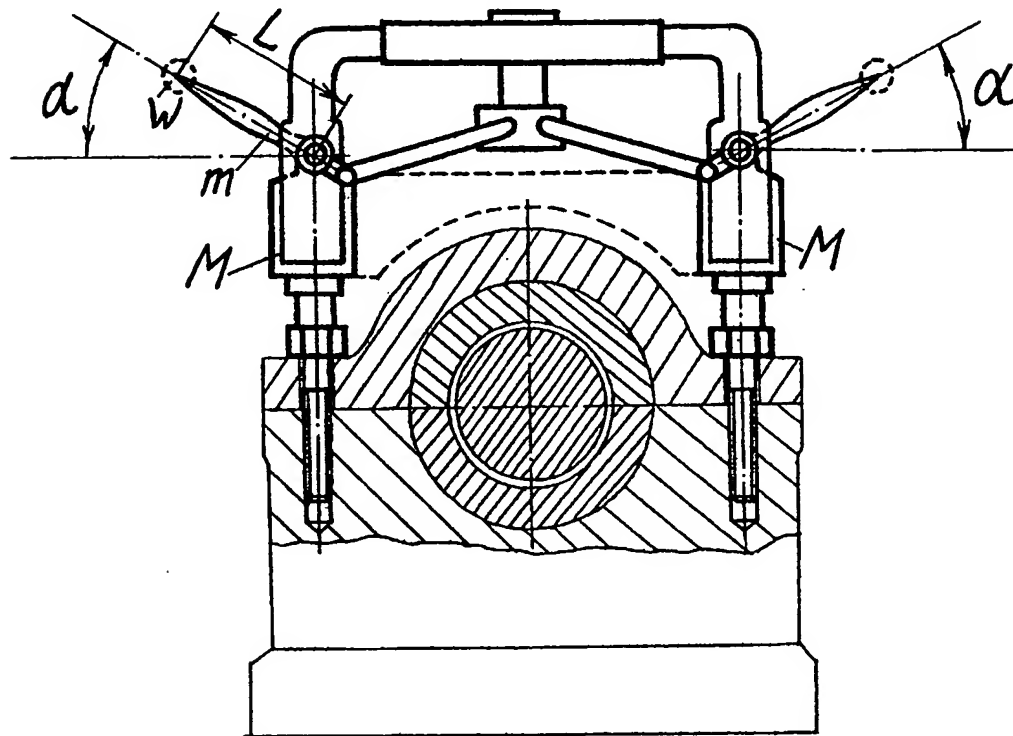
**II: The B-F-L-Ws in a form of specially designed bearing housings in future designed T-G-Ss.**



**Cont.**

+

**Turbine Generator Vibration Damper System. Vladilen Safonov.**

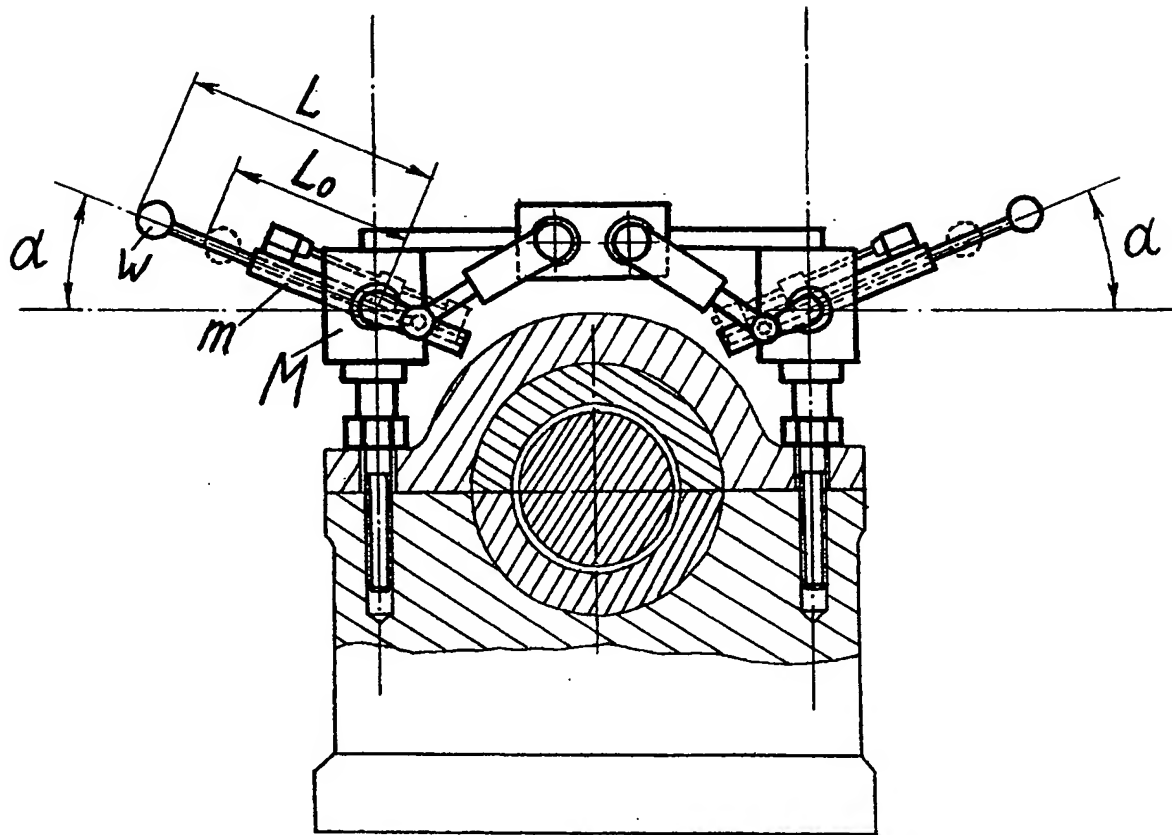


**Bearing-fulcrum of T-G-S**

**Fig. 3 The B-F-L-Ws for removal of beyond-normal vibrations in wide diapasons.**

**For the stated  $M$  &  $L(m, w)$  tuning the system to the vibrations damping is done by changing  $\alpha$ .  
See text in Specification.**

**Turbine Generator Vibration Damper System. Vladilen Safonov.**



**Bearing-fulcrum of T-G-S**

<sup>4</sup>  
**Fig. ~~2a~~ The B-F-L-Ws for removal of beyond-normal vibrations in super-wide diapasons.**

**For the stated  $M$  (and  $m, w$ ) tuning the system to the vibrations damping is done by changing  $L$  and  $\alpha$ .  
See text in Specification.**

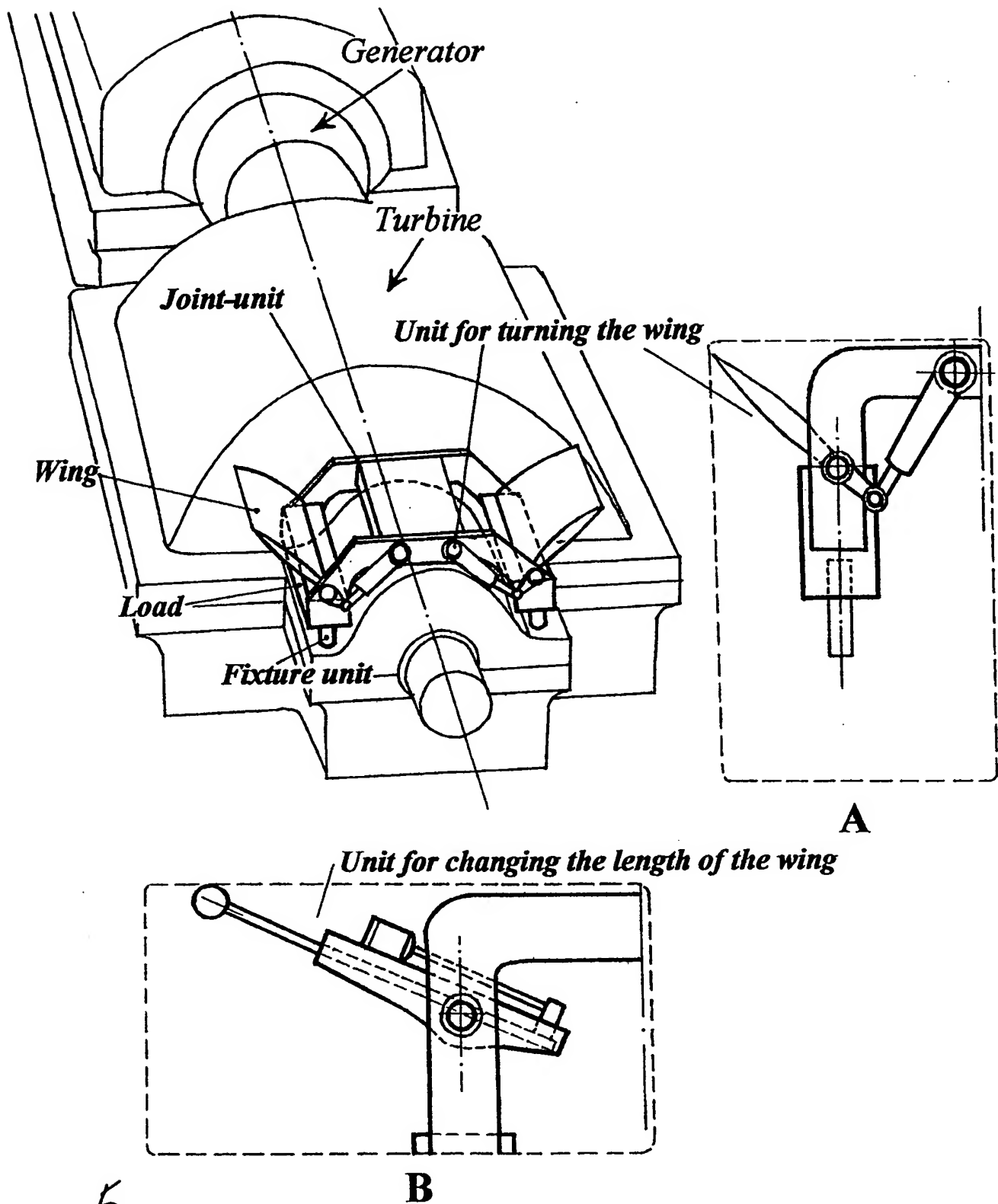
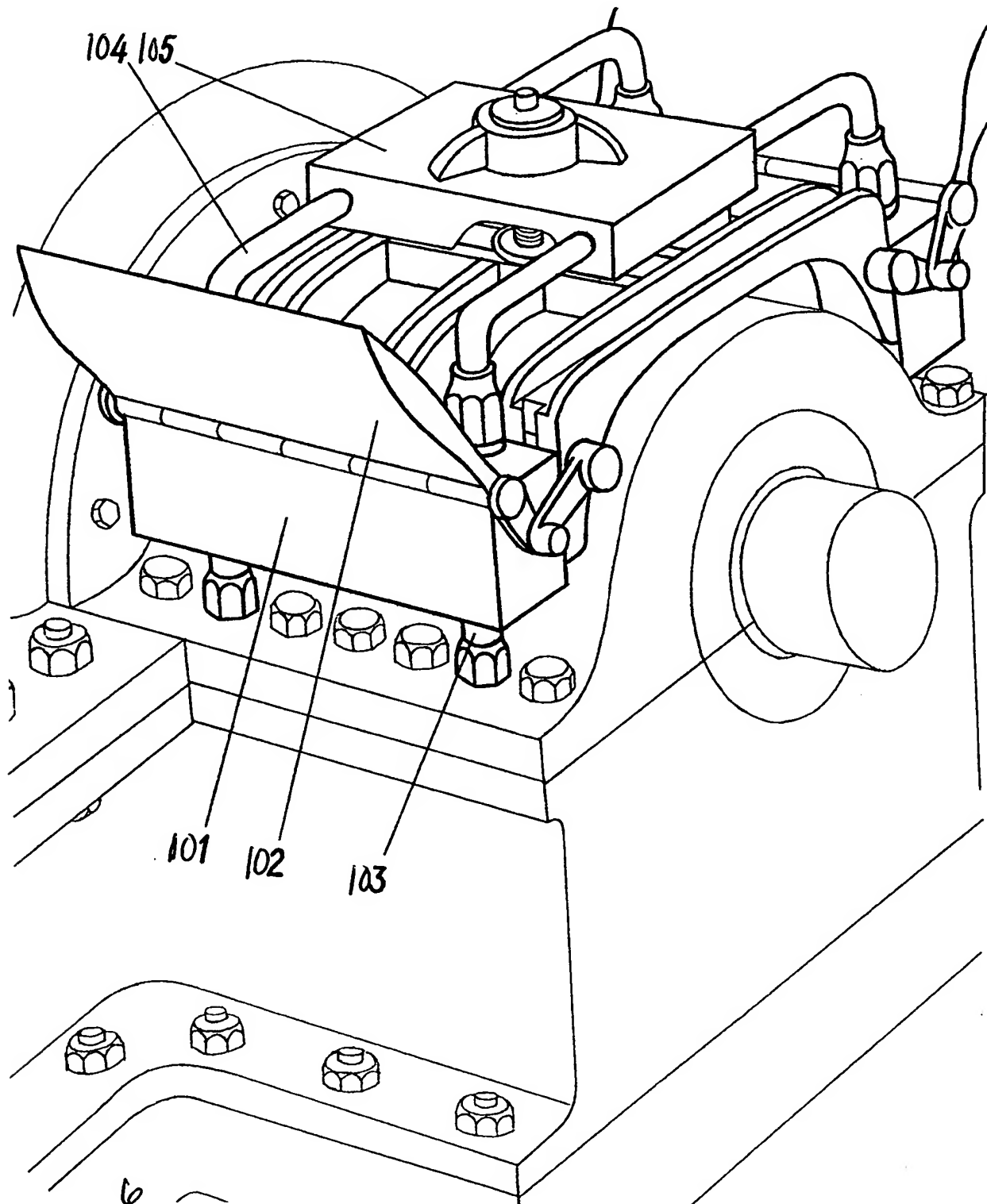


Fig. 5. The main elements of the B-F-L-Ws.

**Turbine Generator Vibration Damper System. Vladilen Safonov.**



**Fig. 3a The B-F-L-Ws for removal of beyond-normal vibrations in wide diapasons (variant). See text in Specification.**

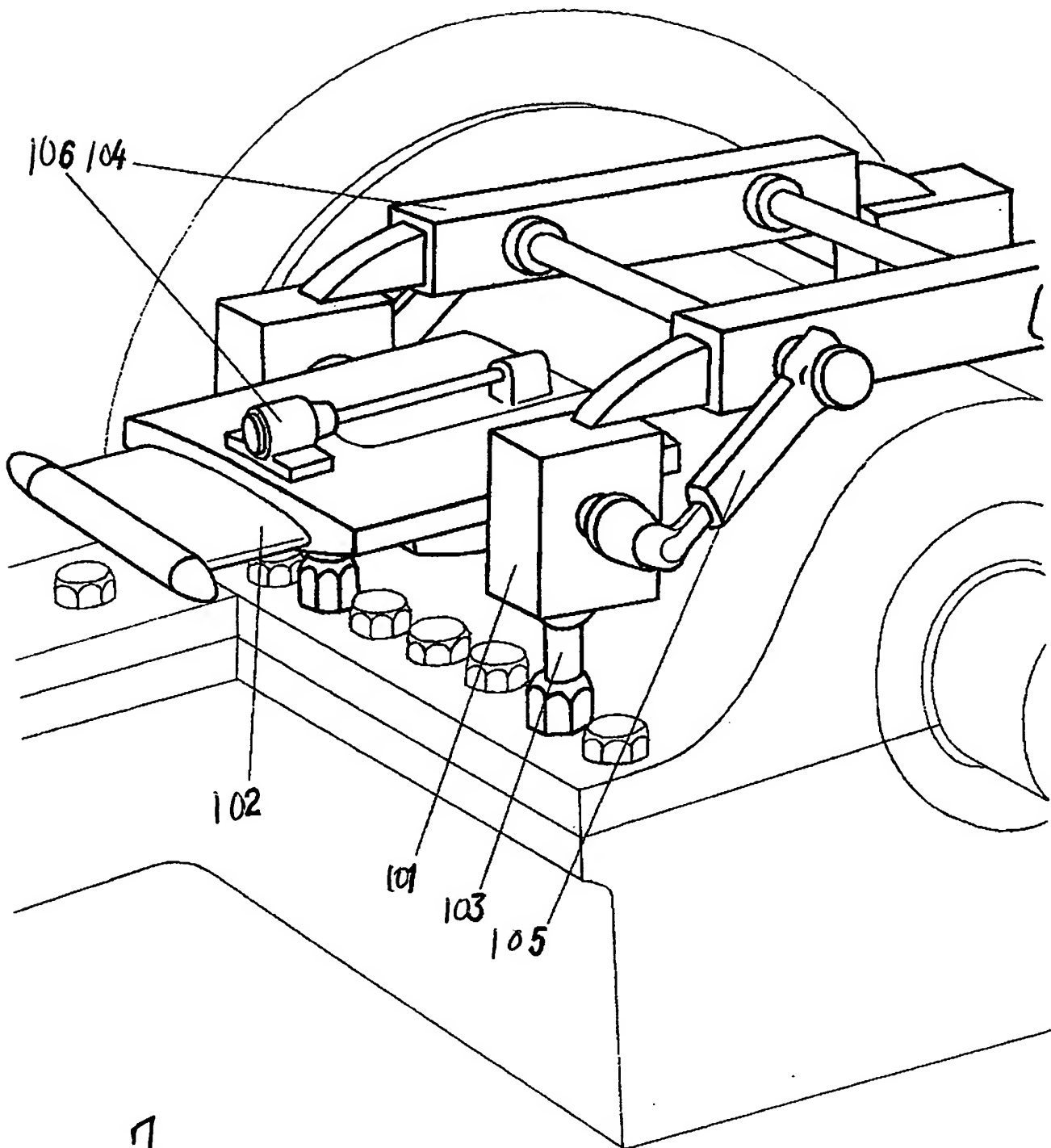
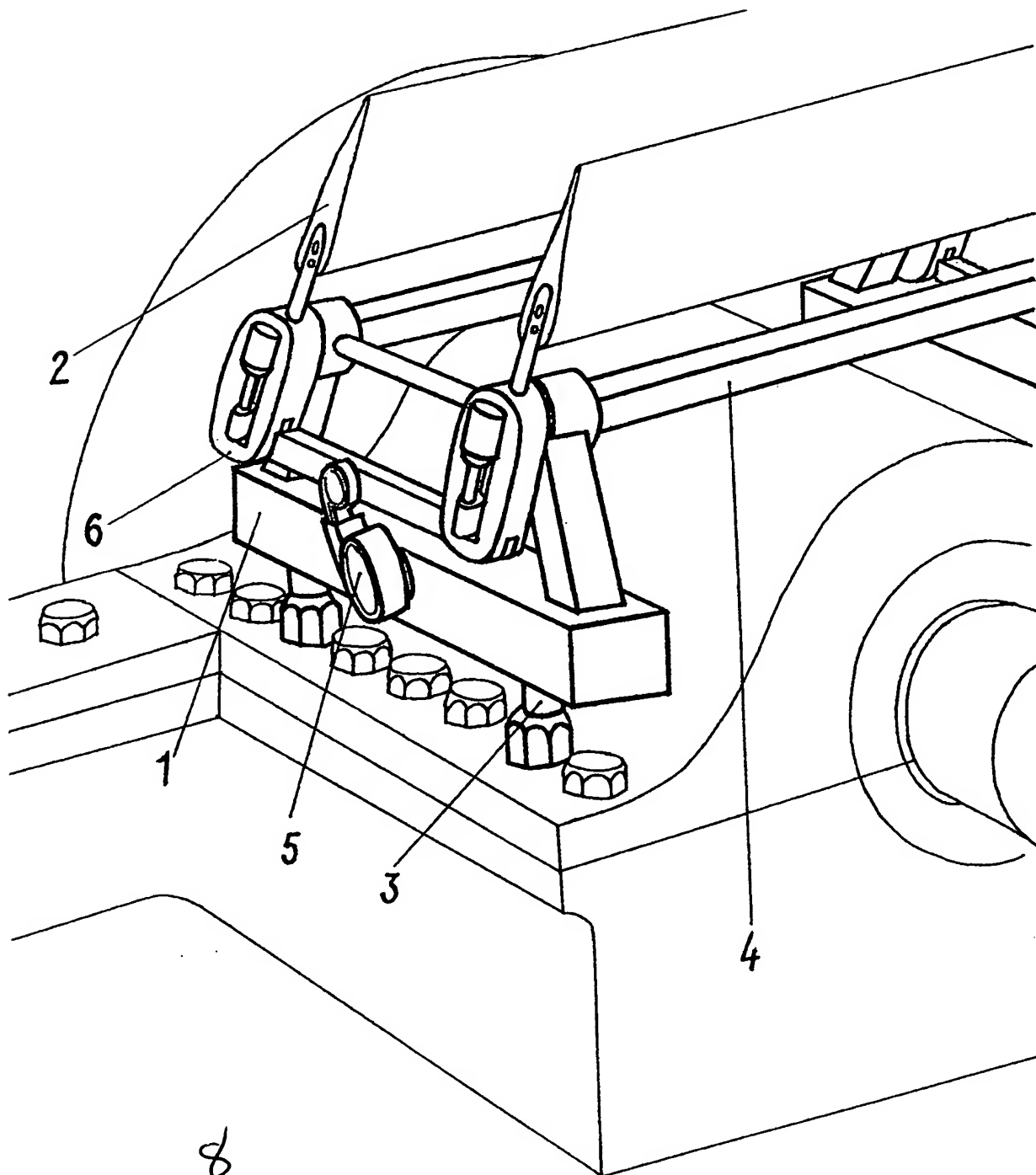


Fig. 3b The B-F-L-Ws for removal of beyond-normal vibrations in super-wide diapasons (variant).  
See text in Specification.

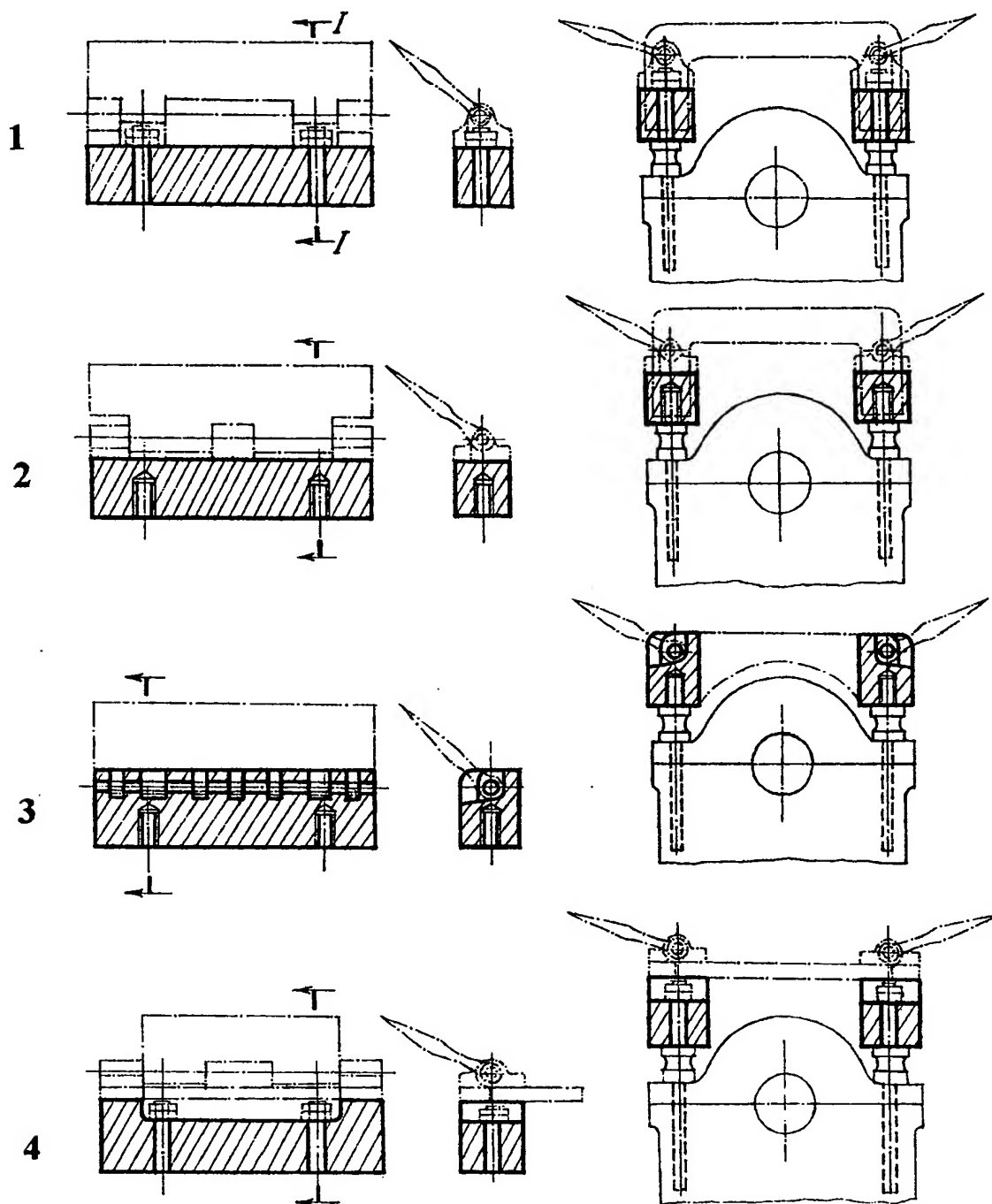
**Turbine Generator Vibration Damper System. Vladilen Safonov.**



**Fig. 8. The B-F-L-Ws for removal of beyond-normal vibrations in super-wide diapasons (variant). Placement in direction perpendicularly to rotor axis of T-G-S. See text in Specification.**



# **Turbine Generator Vibrati n Damper System. Vladilen Safonov.**

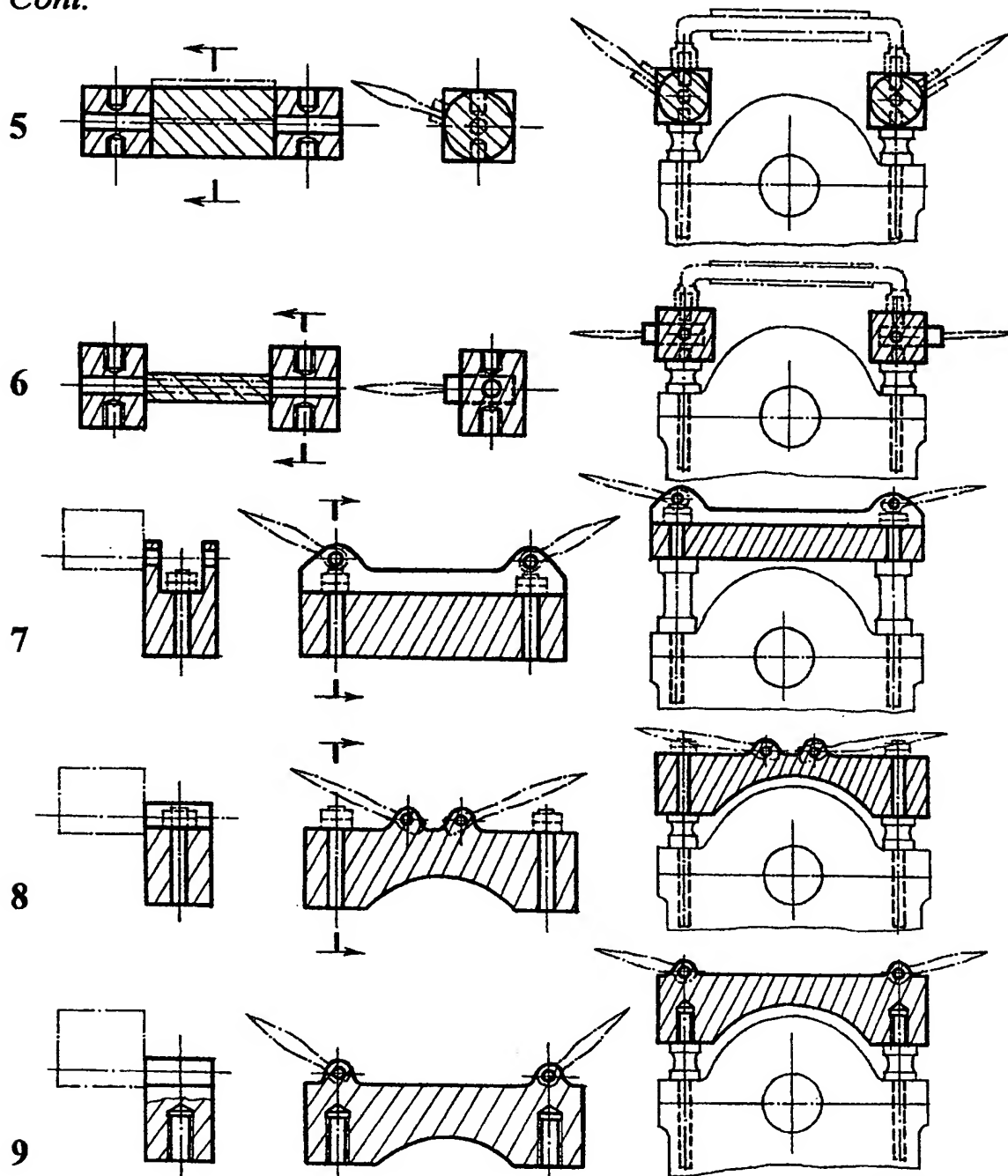


*Cont.*

**Fig. 9 Loads of the B-F-L-Ws (variants).  
Various forms of the loads.**

# **Turbine Generator Vibration Damper System. Vladilen Safonov.**

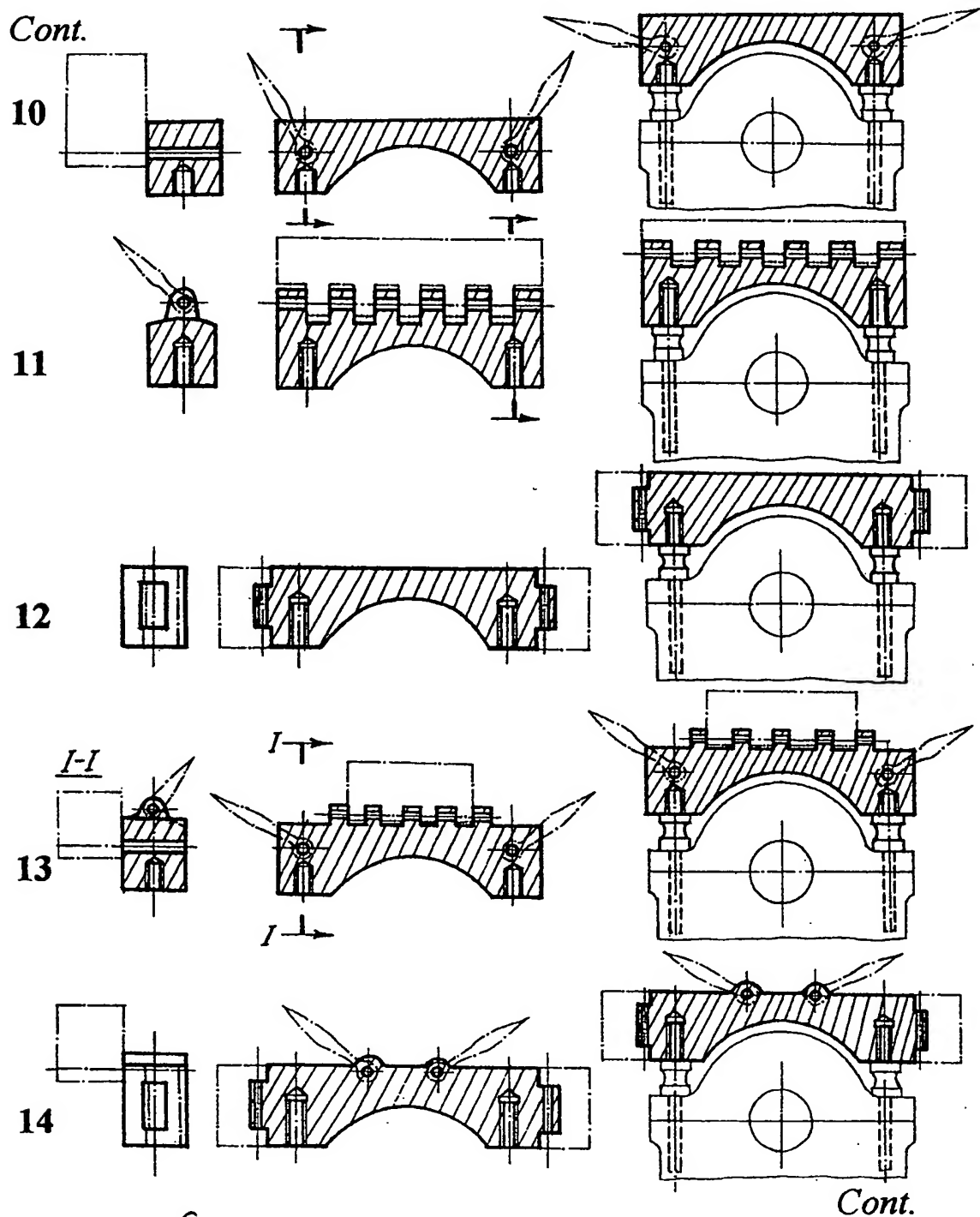
*Cont.*



*Cont.*

**Fig. 9 Continuation. Loads of the B-F-L-Ws (variants). Various forms of the loads.**

# **Turbine Generator Vibration Damper System. Vladilen Safonov.**

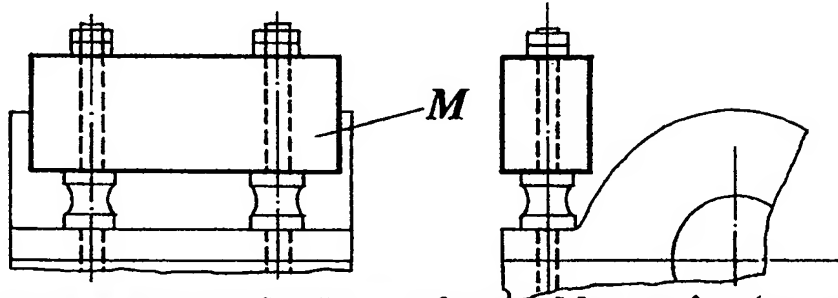


**Fig. 4 Continuation. Loads of the B-F-L-Ws (variants). Various forms of the loads.**

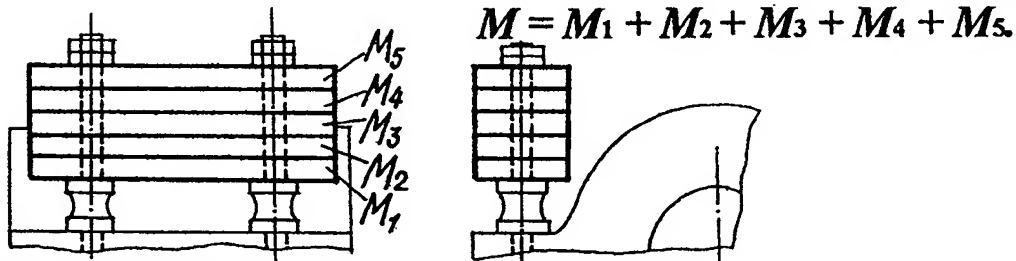
# **Turbine Generator Vibration Damper System. Vladilen Safonov.**

*Cont.*

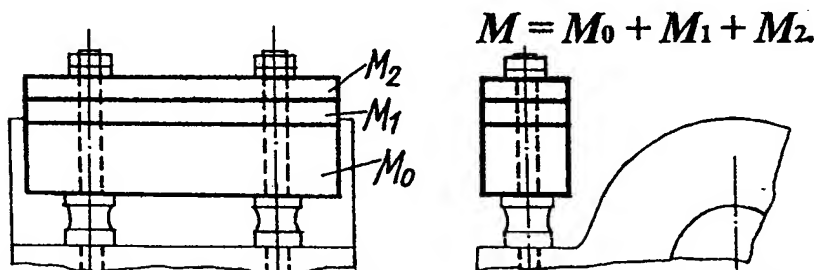
## **15. The ways of forming the loads ( variants ).**



**15a. The stated mass load manufactured by casting ( or pressing, shaping, etc. ).**



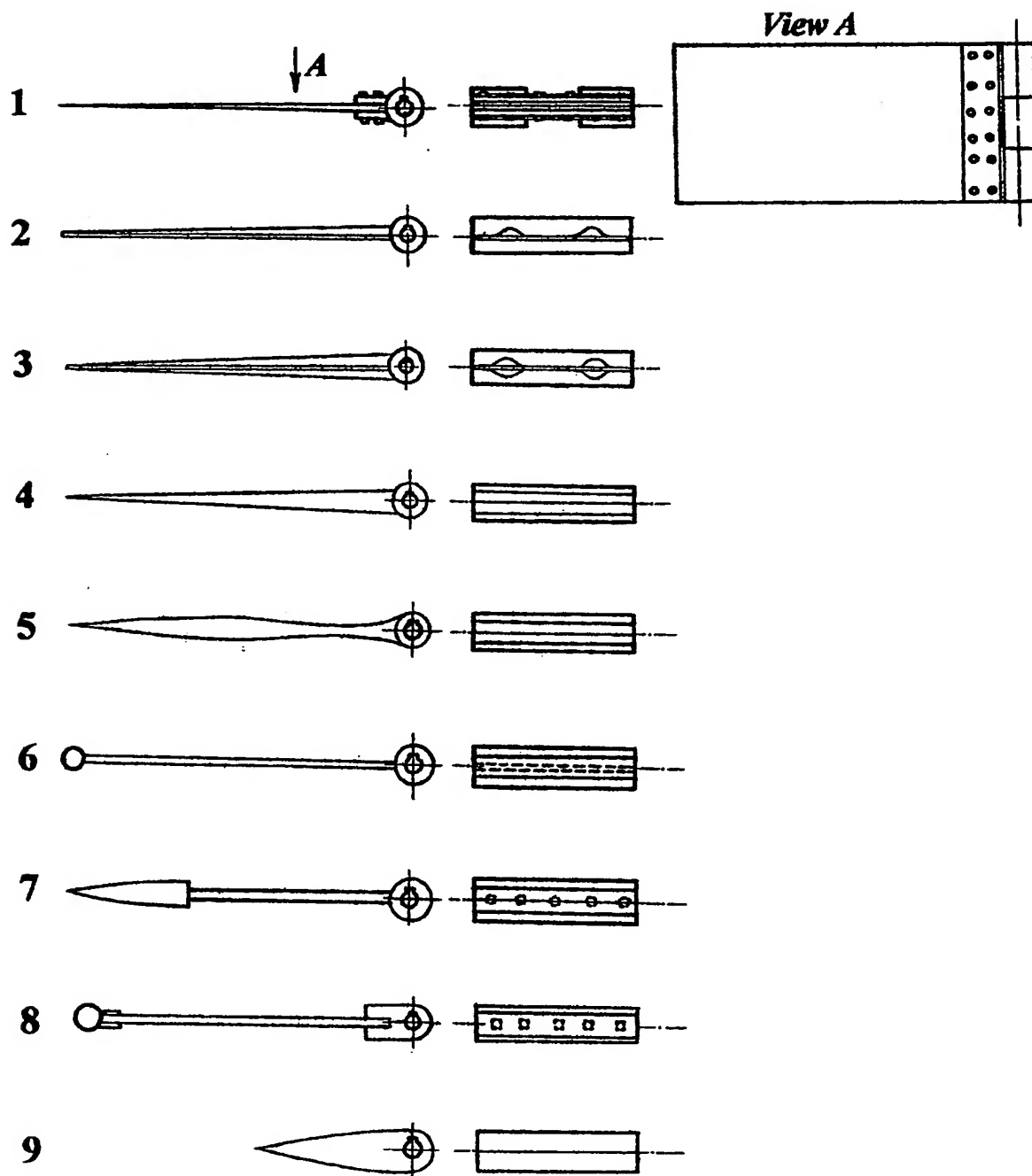
**15b. The stated mass load collected from the weights.**



**15c. The load collected from the basic load and the additional weights.**

**Fig. 9 Continuation. Loads of the B-F-L-Ws (variants).  
The ways of forming the loads.**

**Turbine Generator Vibration Dampening System. Vladilen Safonov.**

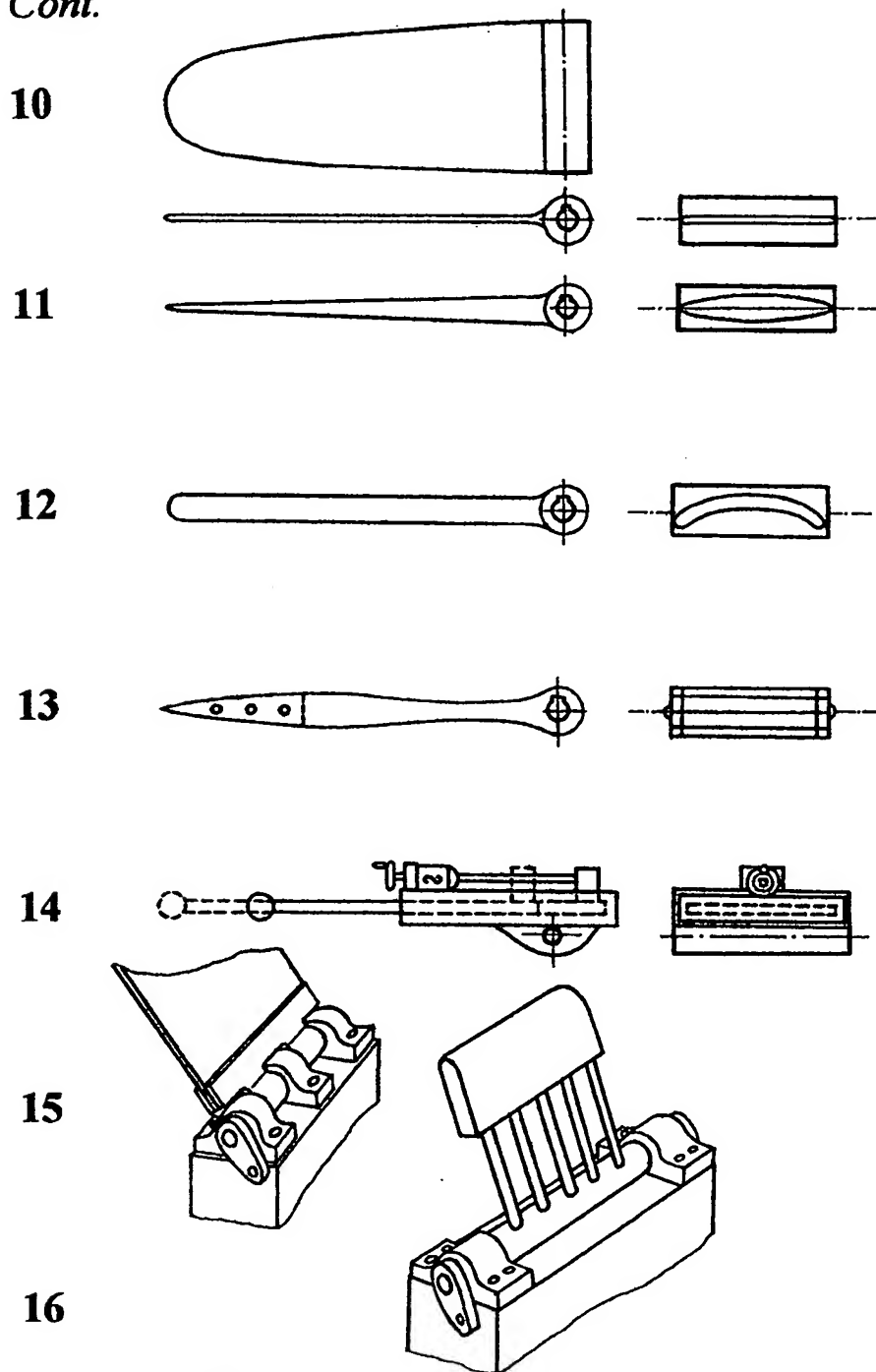


*Cont.*

**Fig. 4a** <sup>10</sup> Wings of the B-F-L-Ws (variants).  
Various forms of the wings.

# **Turbine Generator Vibration Damper System. Vladilen Safonov.**

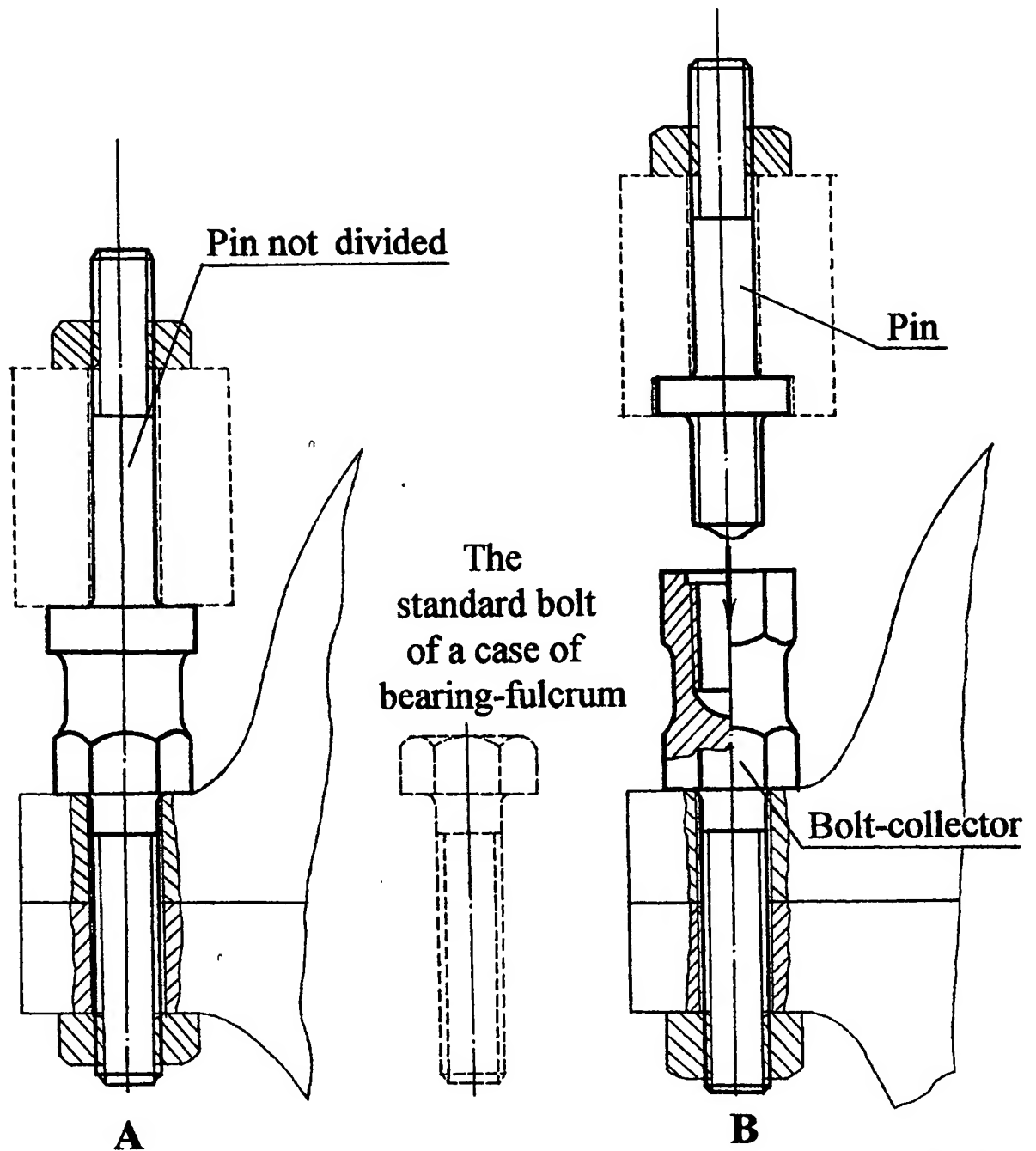
*Cont.*



**Fig. 10 Continuation. Wings of the B-F-L-Ws (variants). Various forms of the wings.**

**See also: Preferable fixations of wings fulcrum (on) to the loads and the joint-units [Fig. 4a (par. 4)], Folding wings of the B-F-L-Ws (Fig. 11a).**

**Turbine Generator Vibration Damper System. Vladilen Safonov.**

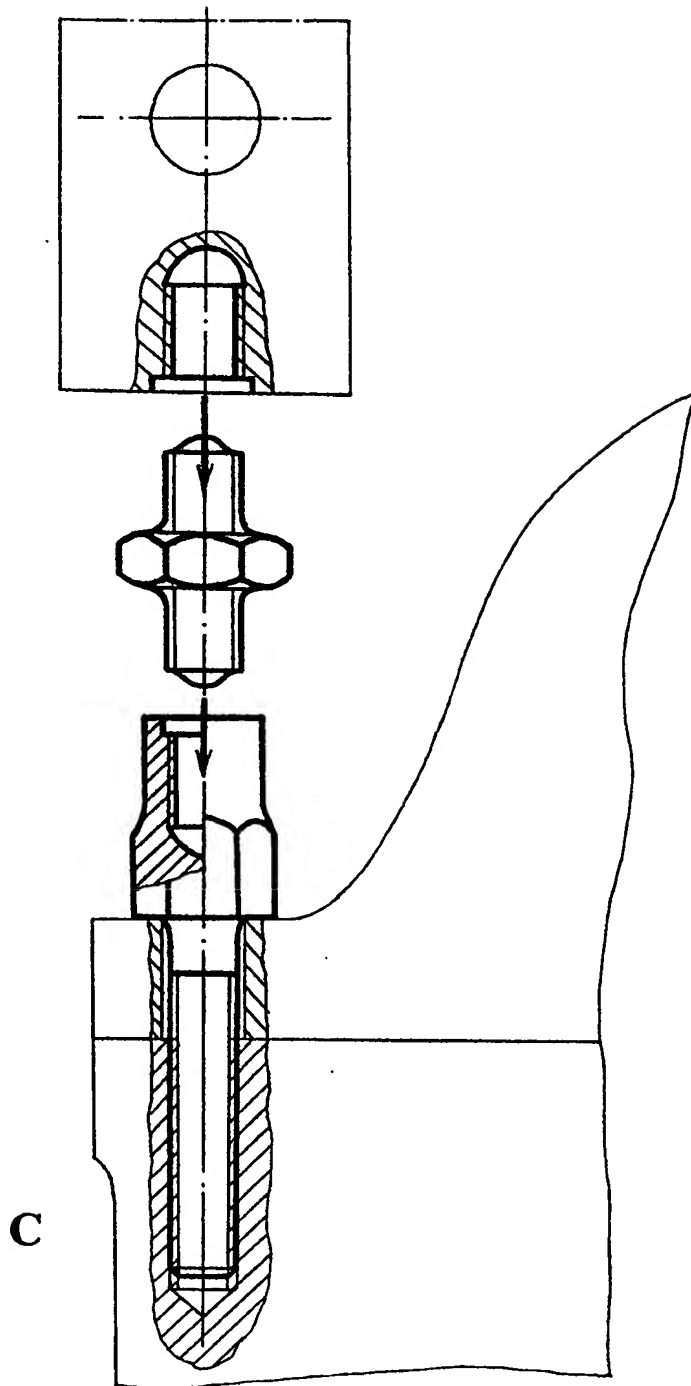


*Cont.*

**Fig. 4b** Fixture units for fixing of loads of the B-F-L-Ws to a case of bearing-fulcrum (variants).

**Turbine Generator Vibration Damper System. Vladilen Safonov.**

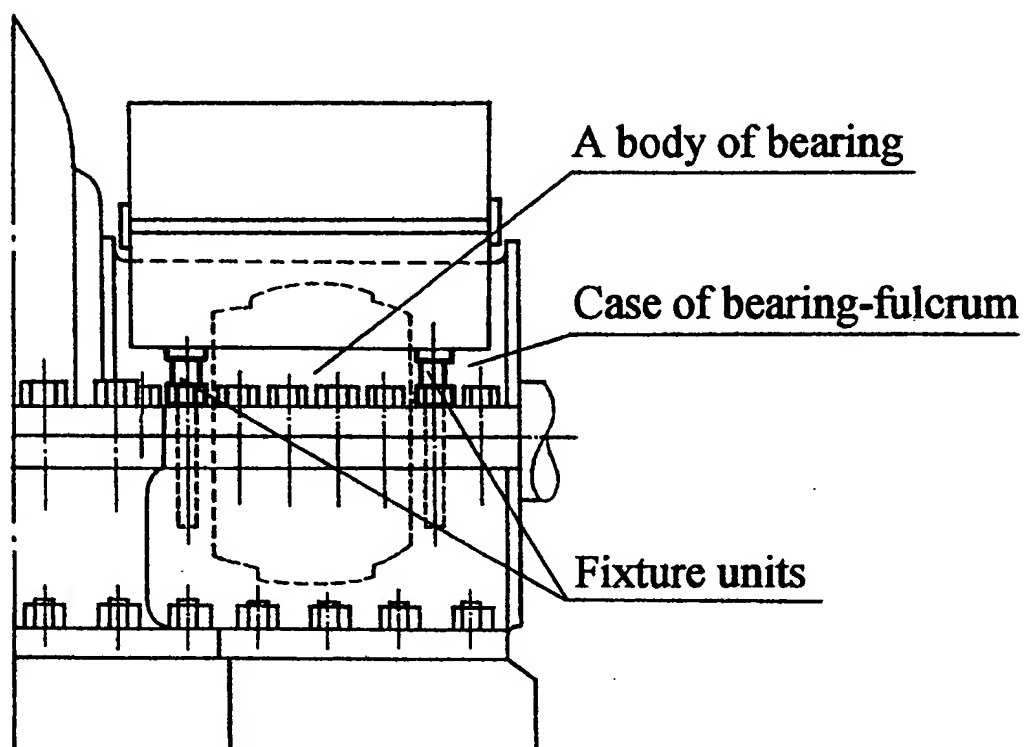
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**Fig. 4b Continuation. Fixture units for fixing loads of the B-F-L-Ws to a case of bearing-fulcrum (variant).**

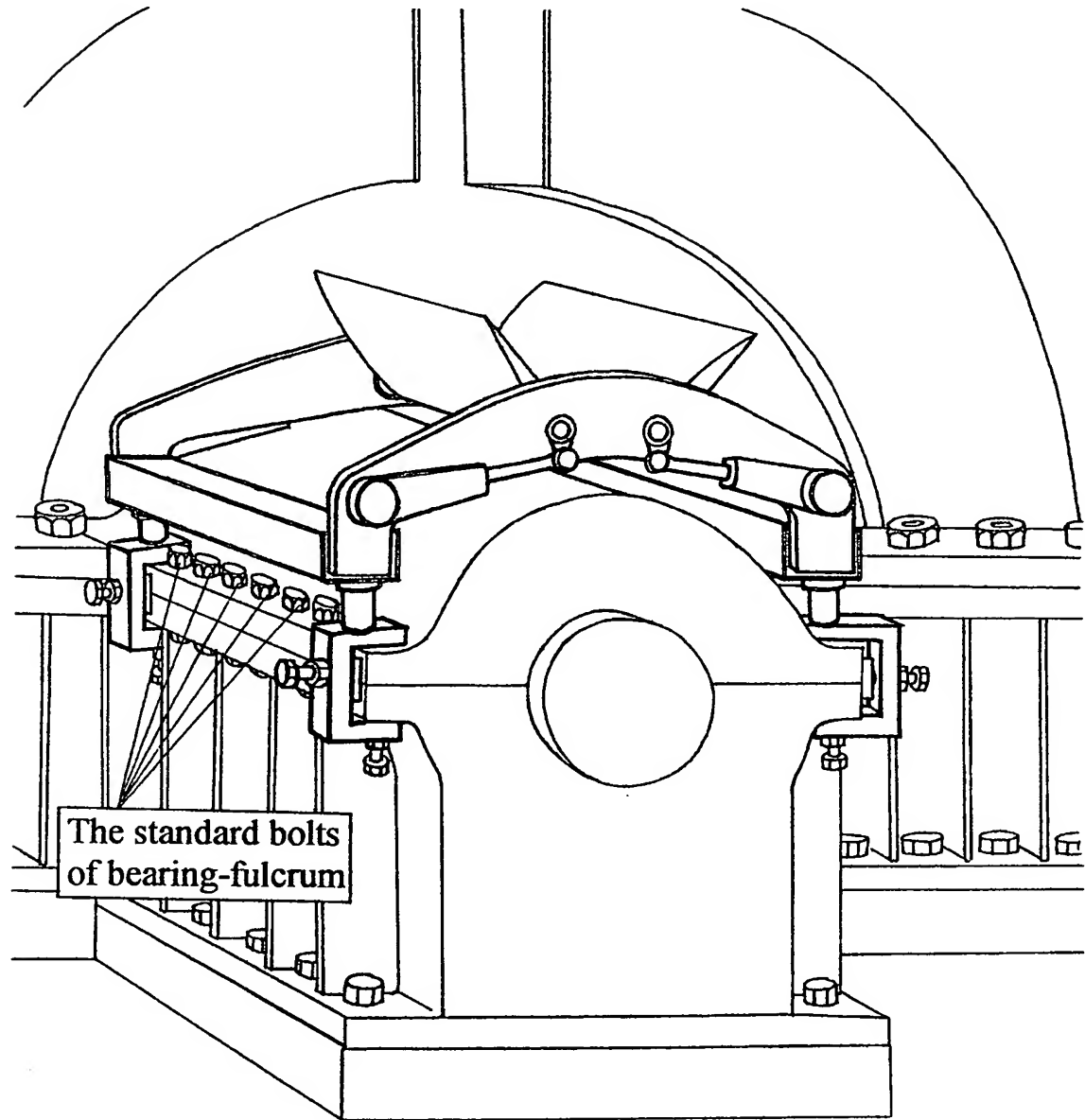


**Turbine Generator Vibration Damper System. Vladilen Safon v.**



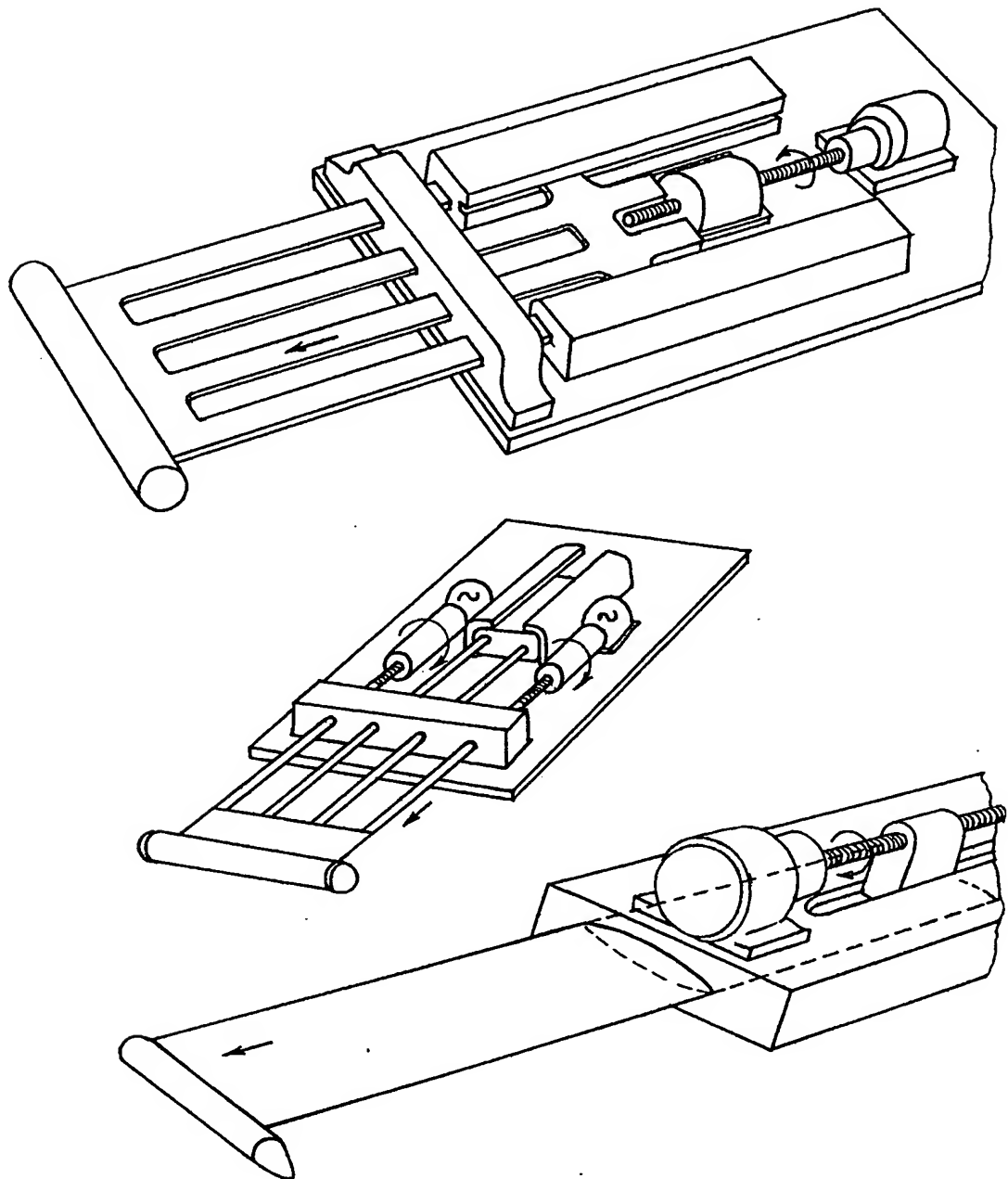
12  
**Fig. 4e Preferable setting of fixture units of the B-F-L-Ws.**

**Turbine Generator Vibration Damper System. Vladilen Safonov.**



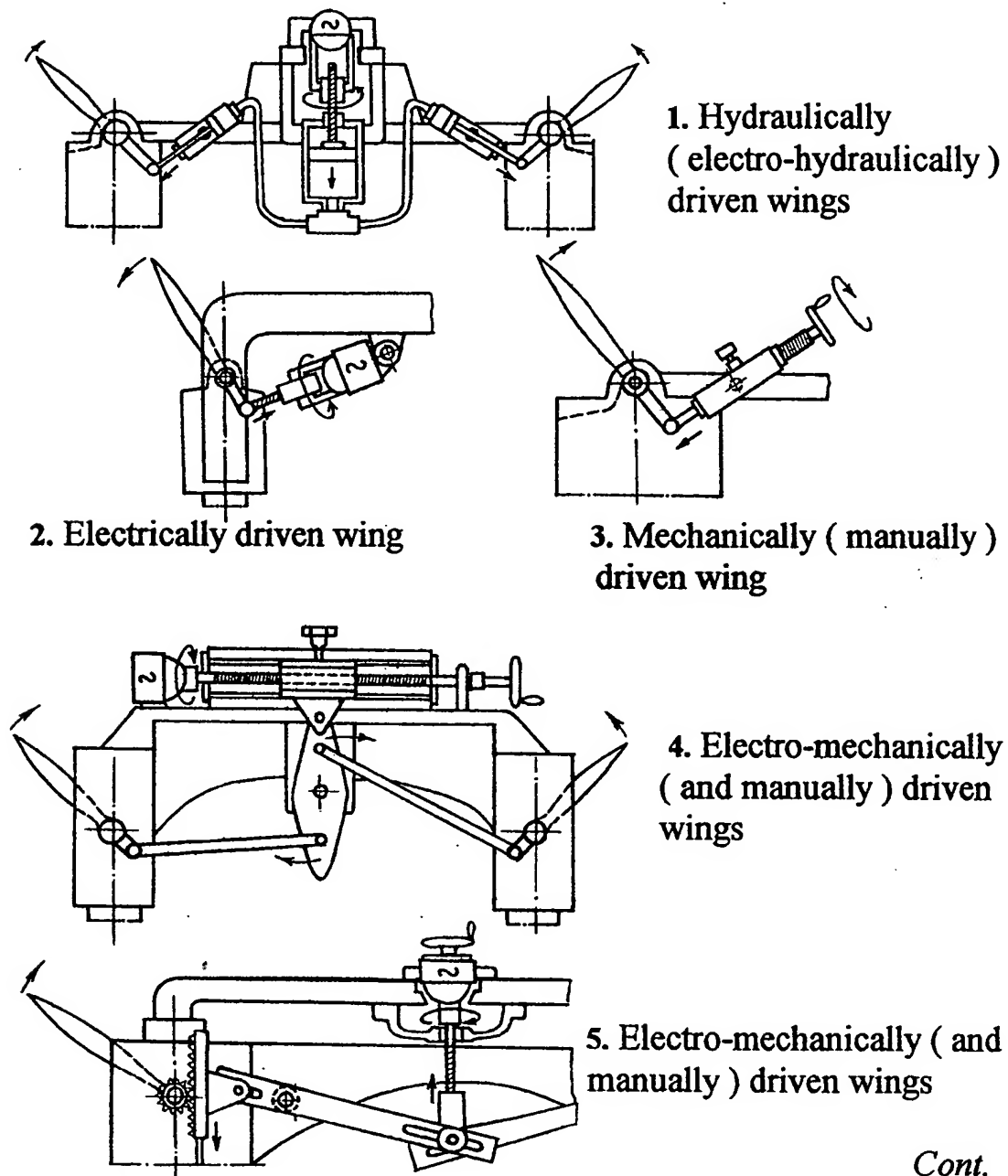
<sup>13</sup>  
**Fig. 41 Installation of the B-F-L-Ws with fixation which not requires replacement of the standard bolts of bearing-fulcrum (variant).**

**Turbine Generator Vibration Damper System. Vladilen Safonov.**



<sup>14</sup>  
**Fig. 4e Variants of units for changing the length of wings  
of the B-F-L-Ws.**  
See text in Specification.

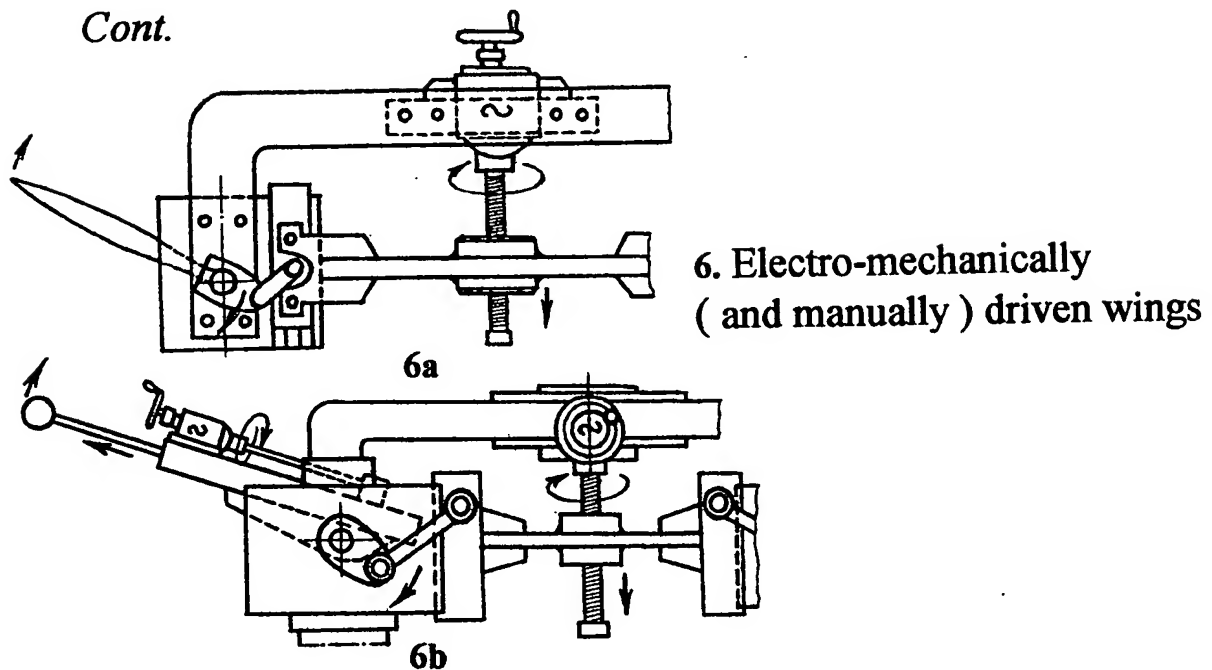
**Turbine Generator Vibration Damper System. Vladilen Safonov.**



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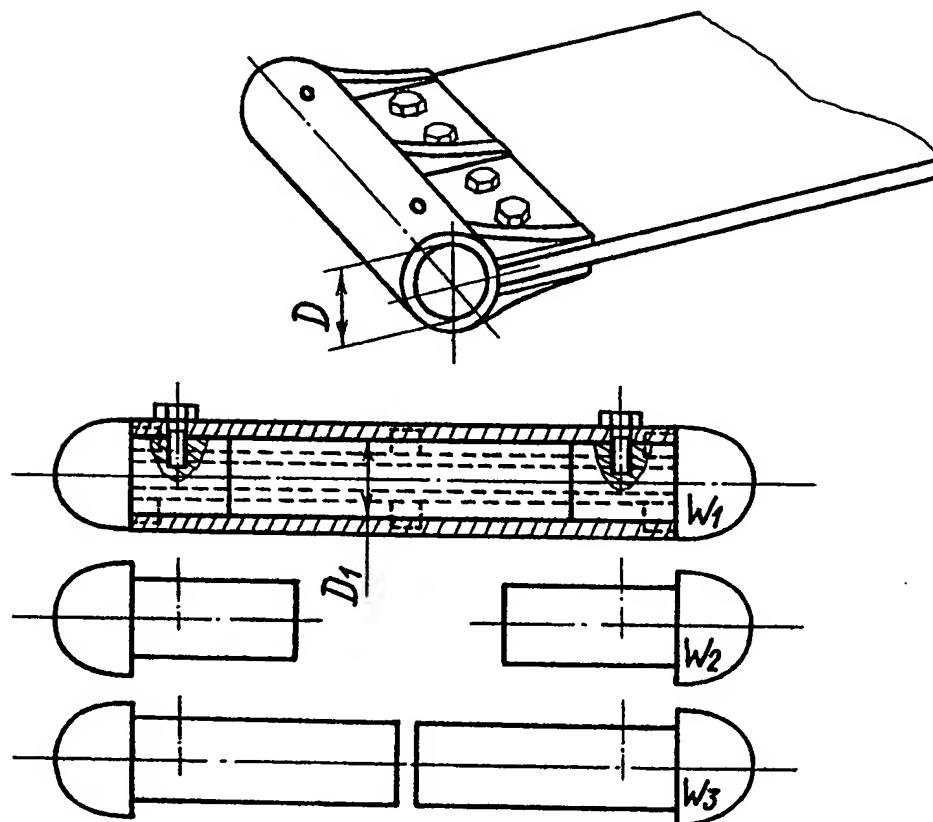
<sup>15</sup>  
**Fig. 4 Various types of drivers (shown schematically) of units for turning wings of the B-F-L-Ws.**  
 See text in Specification.

**Turbine Generator Vibration Damper System. Vladilen Safonov.**



15  
**Fig. 4 Continuation. Various types of drivers (shown schematically) of units for turning wings of the B-F-L-Ws. See text in Specification.**

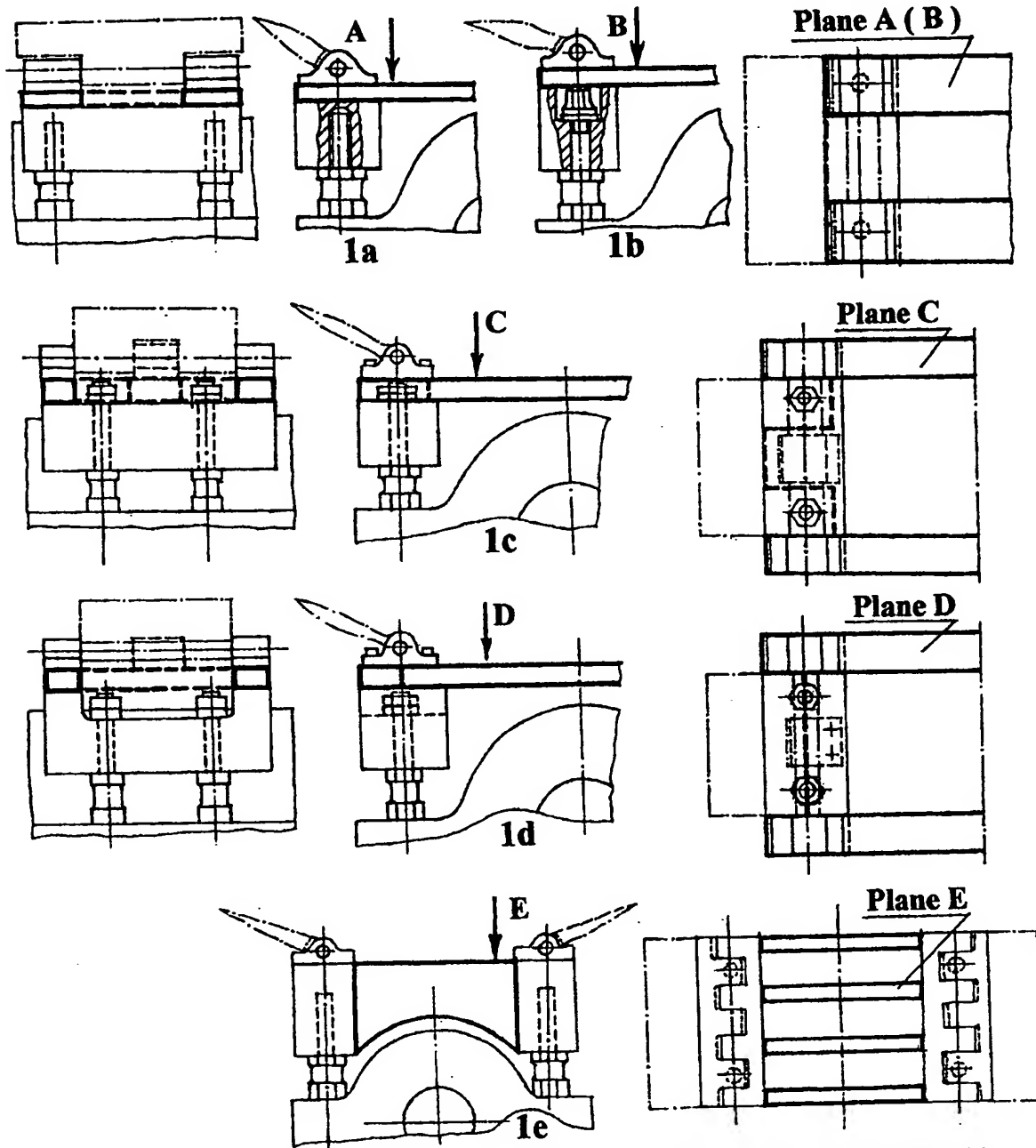
**Turbine Generator Vibration Damper System. Vladilen Safonov.**



**Fig. 4<sup>16</sup> A change of mass of wing of the B-F-L-Ws by attached weights (variant).**

A change may be done by attached pairs of weights of various length and diameter  $D_1, D_2, \dots$ , etc.

**Turbine Generator Vibrati n Damper System. Vladilen Safonov.**



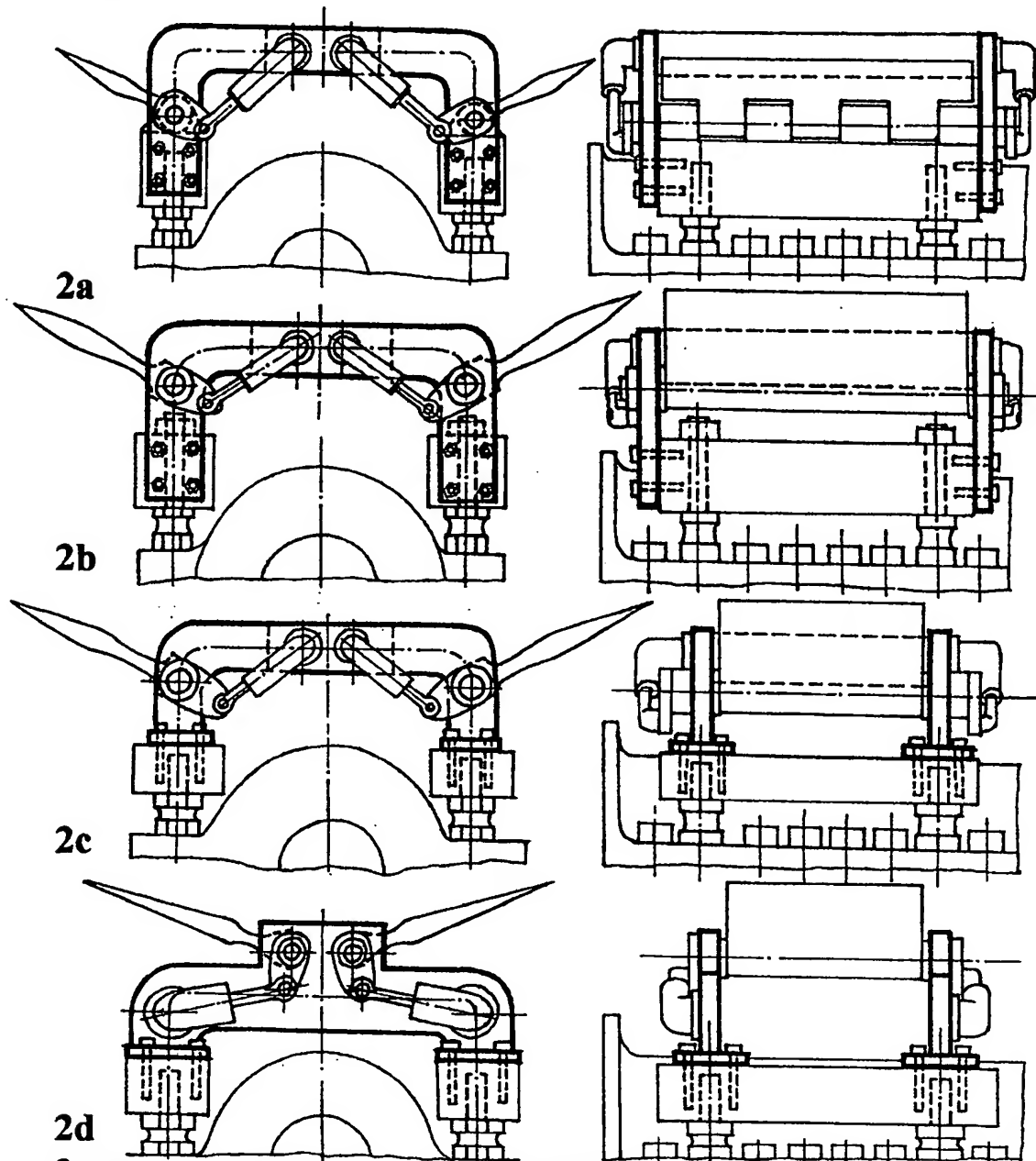
1. The two loads are firmly joined together by the connecting plate(s)  
[ or bars, ribs, etc. ].

*Cont.*

17  
**Fig. 4a Joint-units of the B-F-L-Ws (variants).**

# **Turbine Generator Vibration Damper System. Vladilen Safonov.**

*Cont.*



**2. The two loads are firmly joined together by the connecting arch-shaped units. ( For variants 2b, 2c, 2d wings fulcra are fixed onto the joint-unit ).**

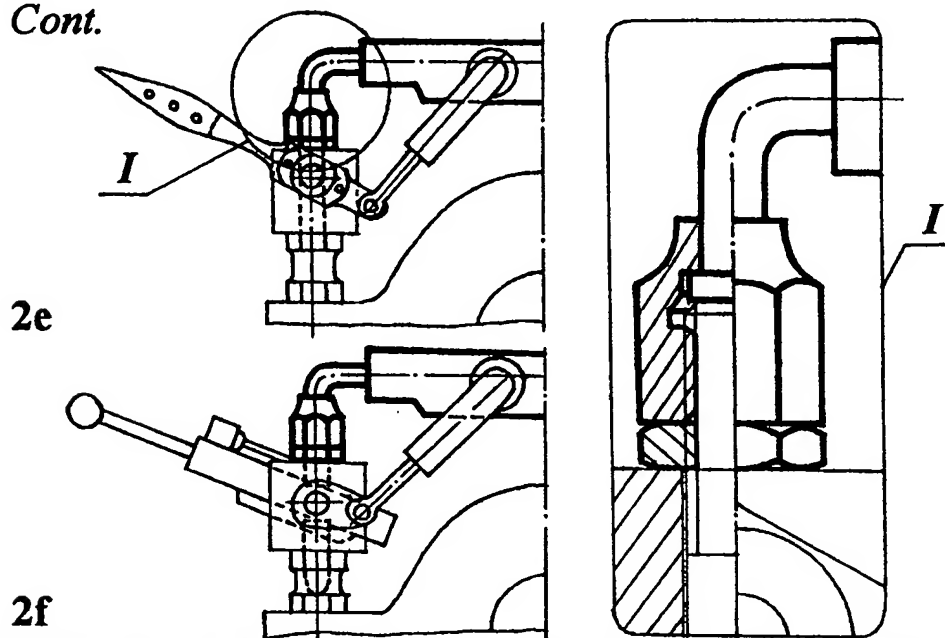
*Cont.*

**Fig. 4<sup>17</sup> Continuation. Joint-units of the B-F-L-Ws (variants).**

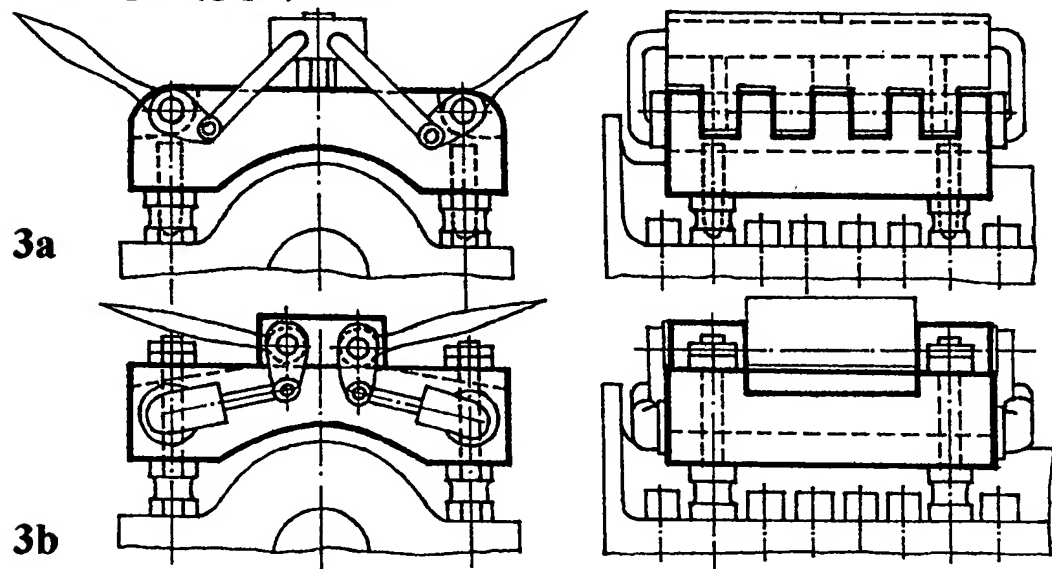


**Turbine Generator Vibration Damper System. Vladilen Safonov.**

*Cont.*



**2. The two loads are firmly joined together by the connecting arch-shaped ( pipe ) units.**

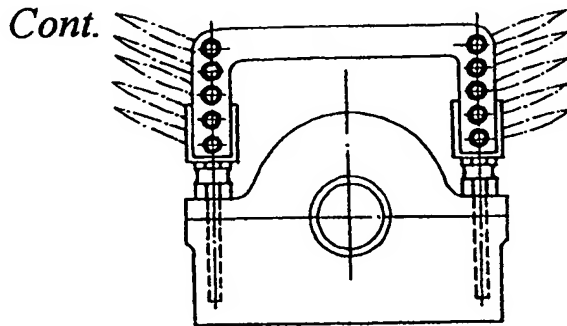


**3. The two loads are manufactured as the whole one ( e.g. by casting, pressing, shaping, etc. ) with the arch jointing. [ For variant 3b wings fulcra are fixed onto the joint-unit ].**

*Cont.*

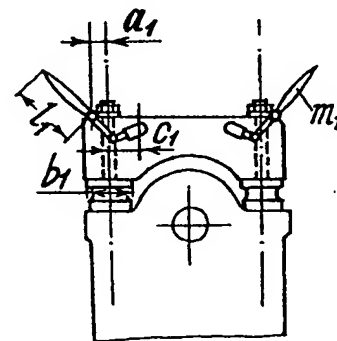
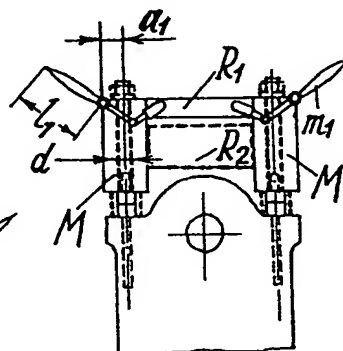
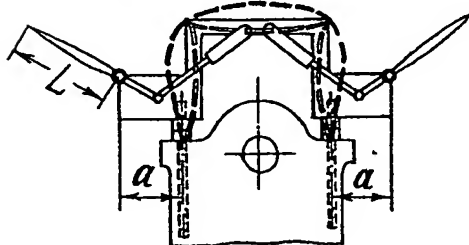
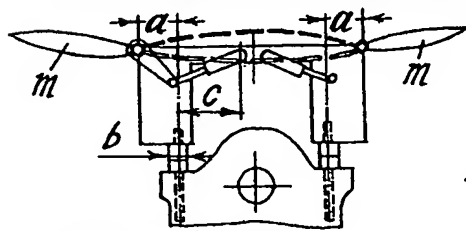
**Fig. 4b Continuation. Joint-units of the B-F-L-Ws (variants).**

# **Turbine Generator Vibrati n Damper System. Vladilen Safonov.**



**4a. The most preferable variants of fixation of wings fulcra (on)to the loads and the joint-units.**

**4b. Fixation with the eccentricity  $a$  ( external ).**



**The recommendations to prefer the fixing of the wings fulcra:**

1)  $a \rightarrow a_1 = a_{\min.}$

2)  $b_1 > b.$

3)  $a_1 < 1/2 b_1.$

4)  $l_1 < L, ( m_1 < m ); c_1 < c.$

5) The system [ formed out of the loads  $M$ , the fixture units  $d$ , the joint-units  $R_1, R_2$  ] is so rigid that it may also successfully resist the additional momentum originated from the eccentricity  $a_1$ .

**4. Some recommendations for preferable fixing of wings fulcra (on)to the loads and the joint-units.**

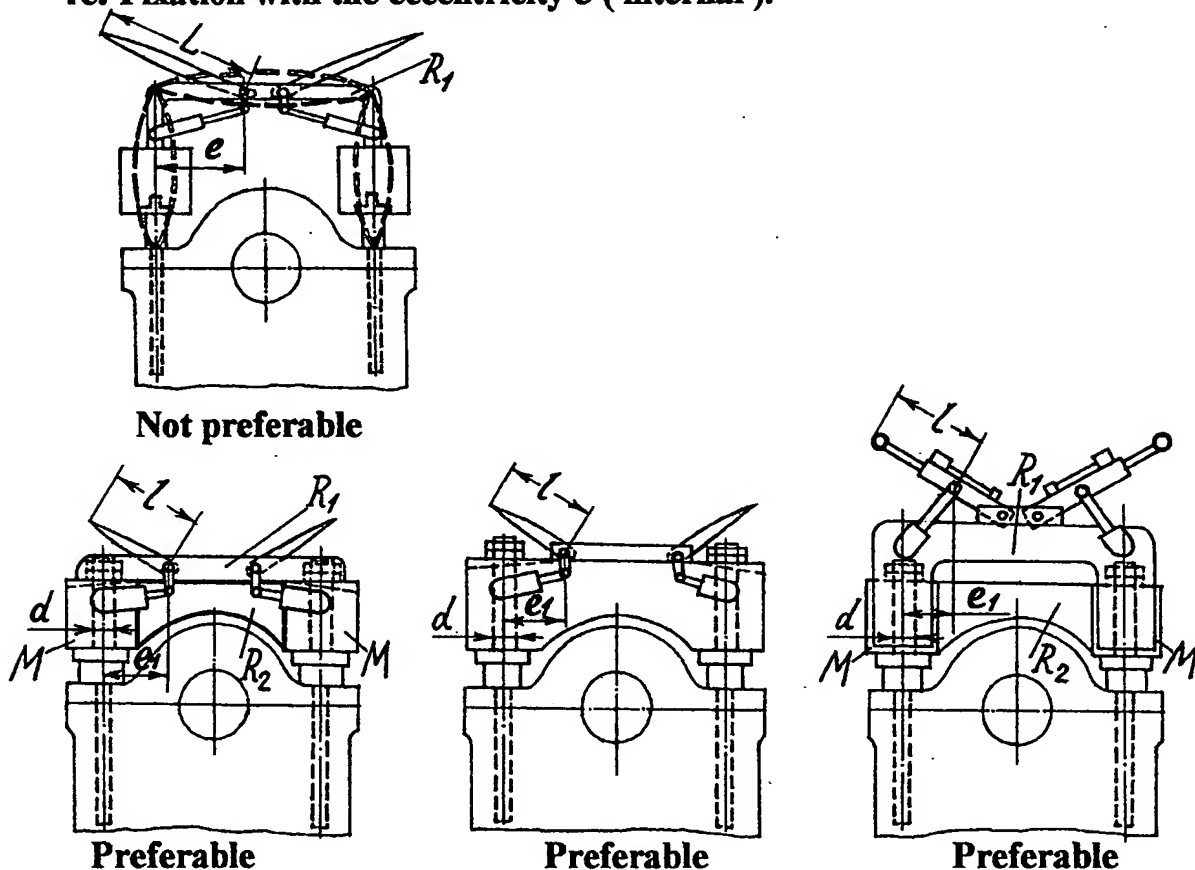
Cont.

**Fig. 4b Continuation. Joint-units of the B-F-L-Ws (variants).**

# **Turbine Generator Vibration Damper System. Vladilen Safonov.**

*Cont.*

**4c. Fixation with the eccentricity  $e$  ( internal ).**



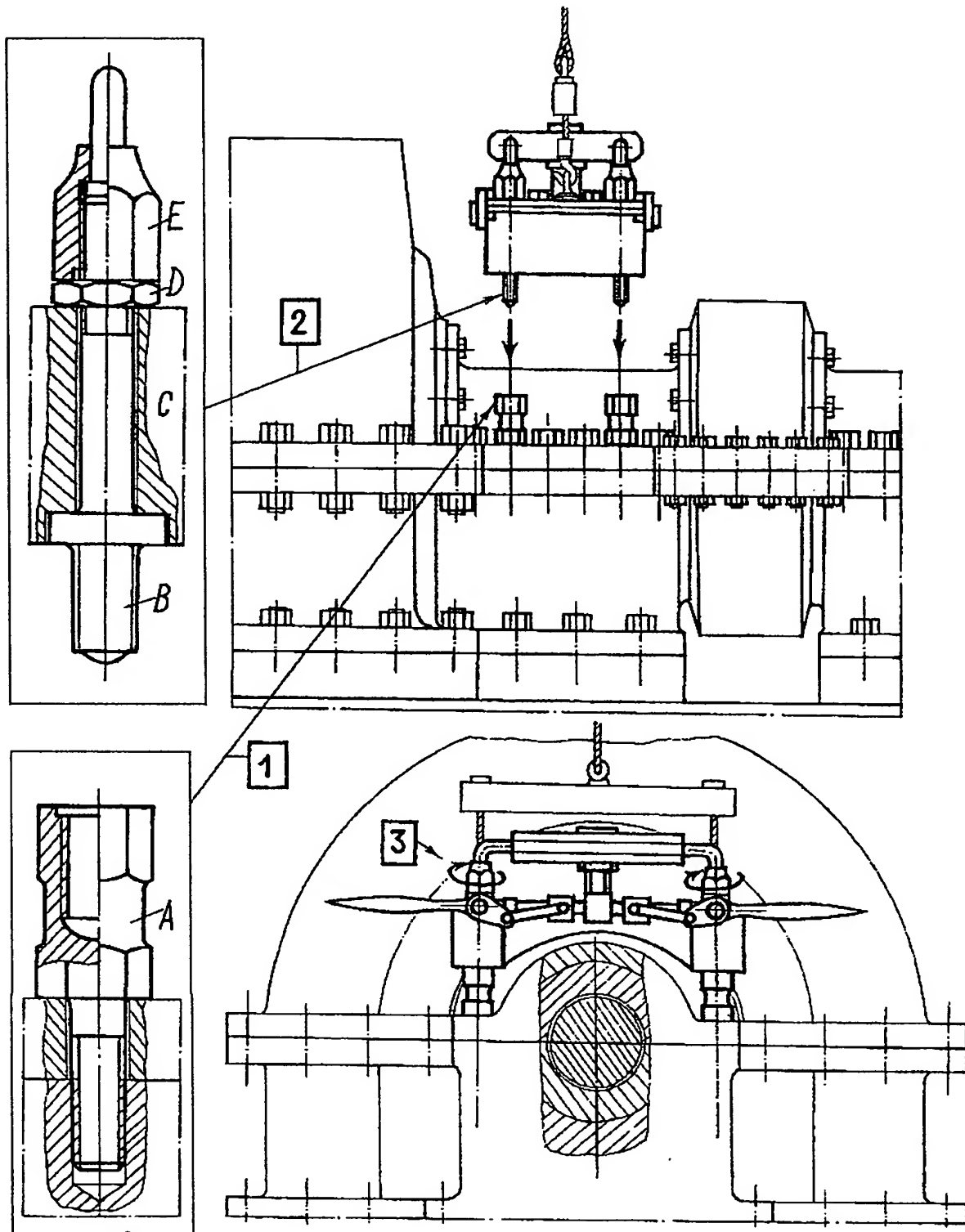
**The recommendations to prefer the fixing of the wings fulcra:**

- 1)  $e, e_1 \rightarrow e_{\min.}$
- 2)  $l < L$  ( e.g. work within limited space for spreading the wings ).
- 3) The system [ formed out of the loads  $M$ , the fixture units  $d$ , the joint-units  $R_1, R_2$  ] is so rigid that it may also successfully resist the additional momentum originated from eccentricity  $e_1$ .

**4. Some recommendations for preferable fixing of wings fulcra (on)to the loads and the joint-units.**

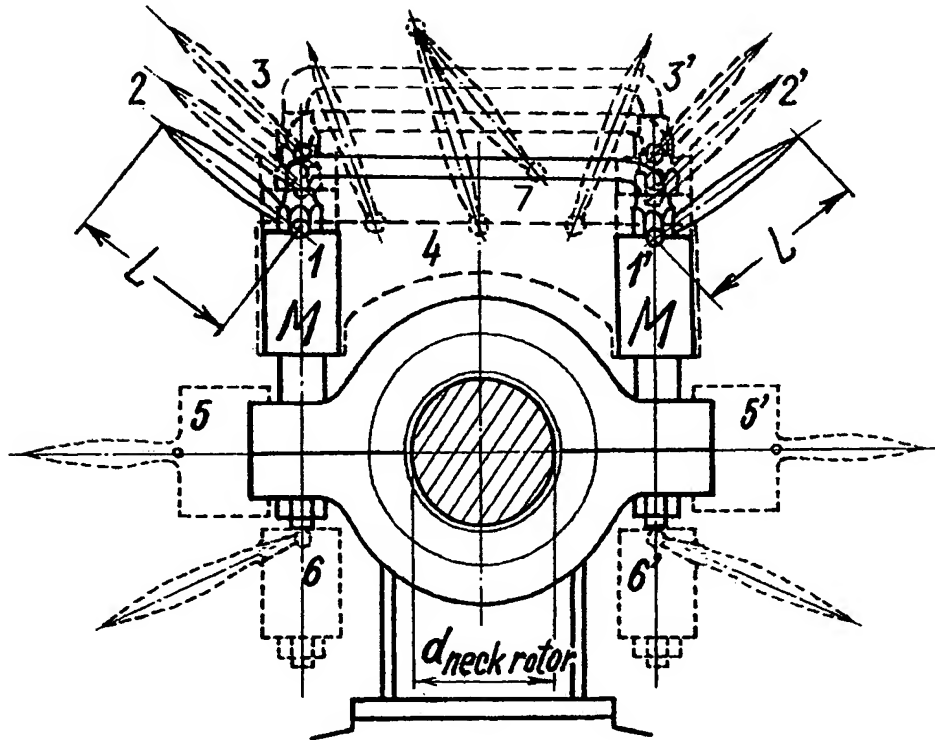
**Fig. 4a Continuation. Joint-units of the B-F-L-Ws (variants).**

# **Turbine Generator Vibration Damper System. Vladilen Safonov.**



**Fig. 4 Operations (in number and sequence) to install the B-F-L-Ws [variant]. See text in Specification.**

## Turbine Generator Vibration Damper System. Vladilen Safonov.



**Fig.19 Placement of the B-F-L-Ws around bearing-fulcrum at T-G-S in direction parallelly to rotor axis.**

**Placement:**

**(1 & 1') - the most adequate and practically possible variant.**

**(2 & 2'), (3 & 3') - additional (and limited) variants.**

**(1 & 1') + (6 & 6') – adequate, but practically not always possible variant.**

**(4) – most adequate variant.**

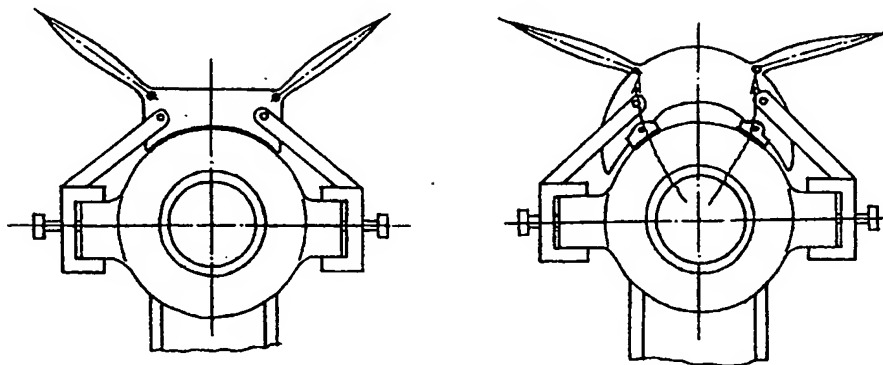
**(5 & 5') - adequate, but practically not always possible variant.**

**(6 & 6') - adequate, but practically not always possible; not preferable variant as not increasing the weight of an upper cover of bearing-fulcrum. Loads may be used with wings, or without wings (as additional variant).**

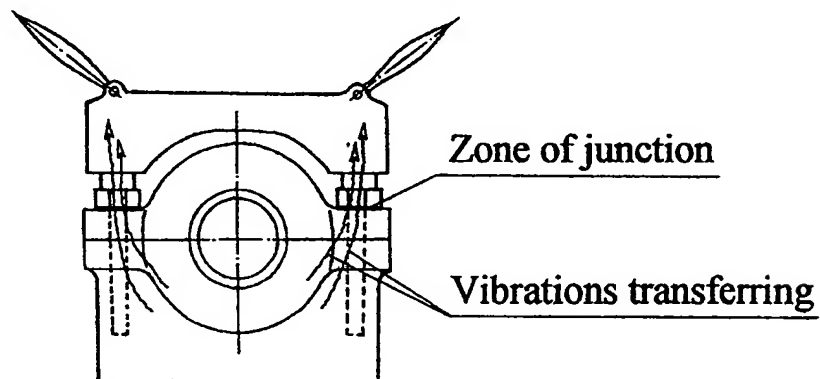
**(7) - adequate, but practically not always possible variant.**

**Here the wing is shown folding (and changeable in length, width and weight).**

**Turbine Generator Vibration Damper System. Vladilen Saf nov.**



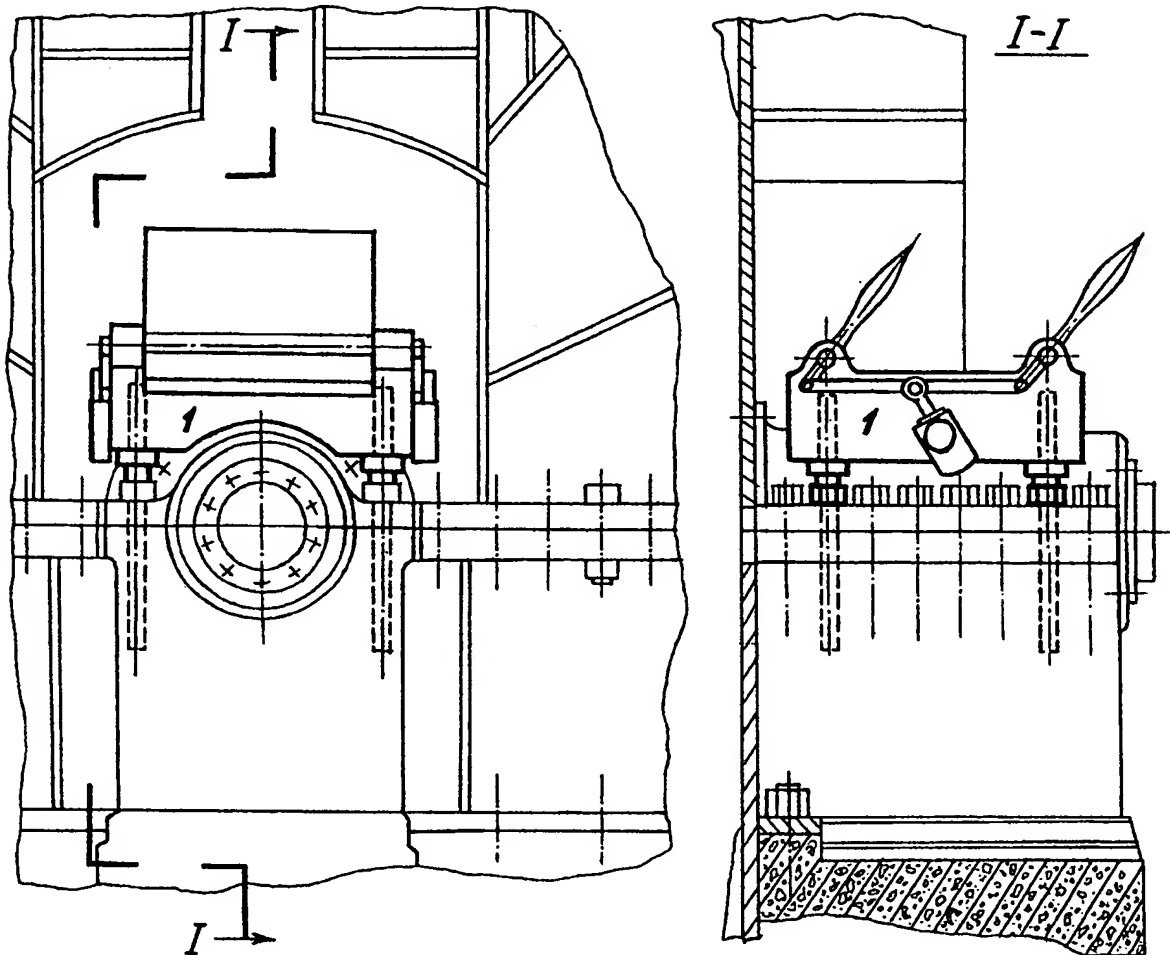
**1) Incorrect placements.**



**2) Correct placement.**

**20**  
**Fig. 2a Correct and incorrect placements of the B-F-L-Ws at bearing-fulcrum /if to follow the instructions of the B-F-L-Ws method/.  
See text in Specification.**

**Turbine Generator Vibration Damper System. Vladilen Safonov.**



**An axial stress bearing-fulcrum**

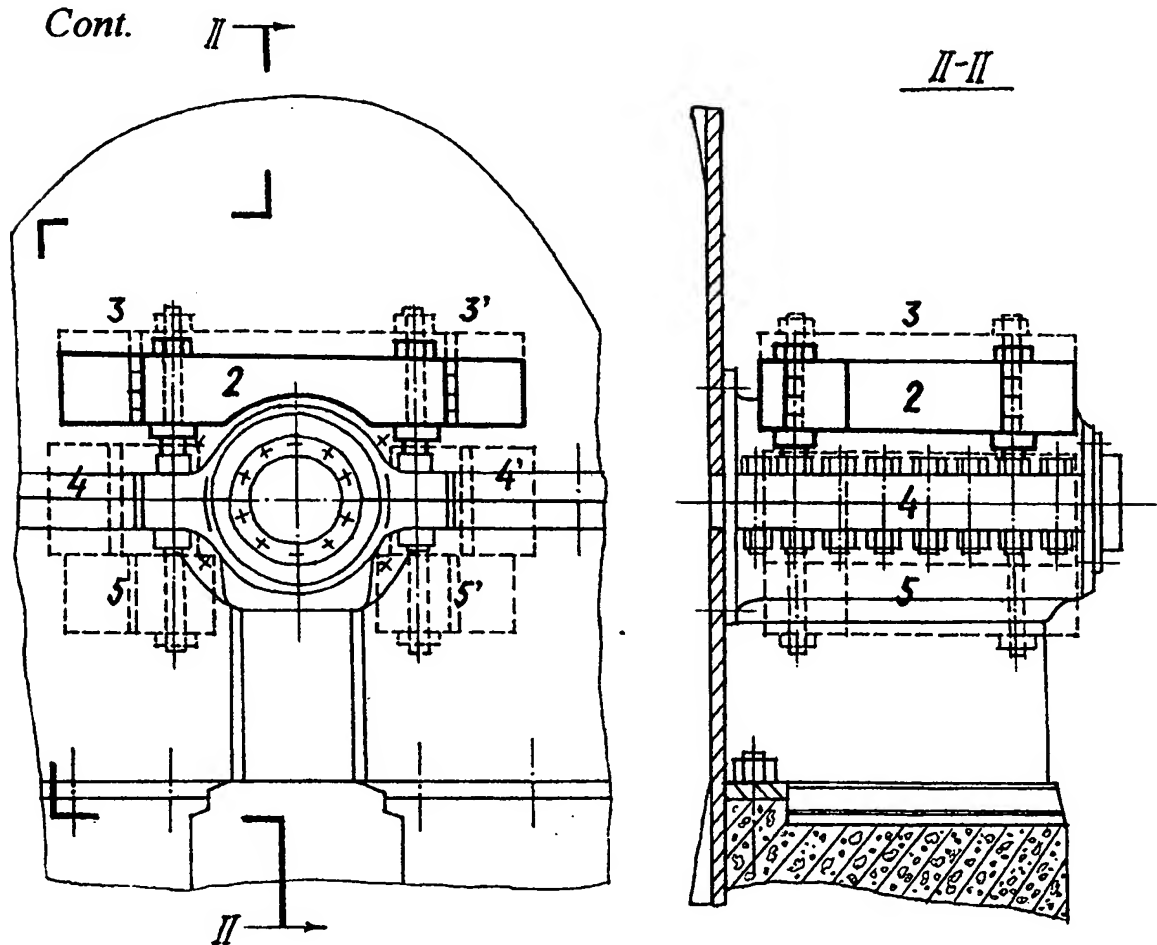
*Cont.*

21  
**Fig. 21** Placement of the B-F-L-Ws upon bearing-fulcrum at T-G-S in direction perpendicularly to rotor axis.

**Placement:**

**1 - the most adequate and practically possible variant.**

**Turbine Generator Vibration Damper System. Vladilen Safonov.**



21  
**Fig. 21 Continuation. Placements of the B-F-L-Ws around bearing-fulcrum at T-G-S in direction perpendicularly to rotor axis.**

**Placements:**

**2 - most adequate variant.**

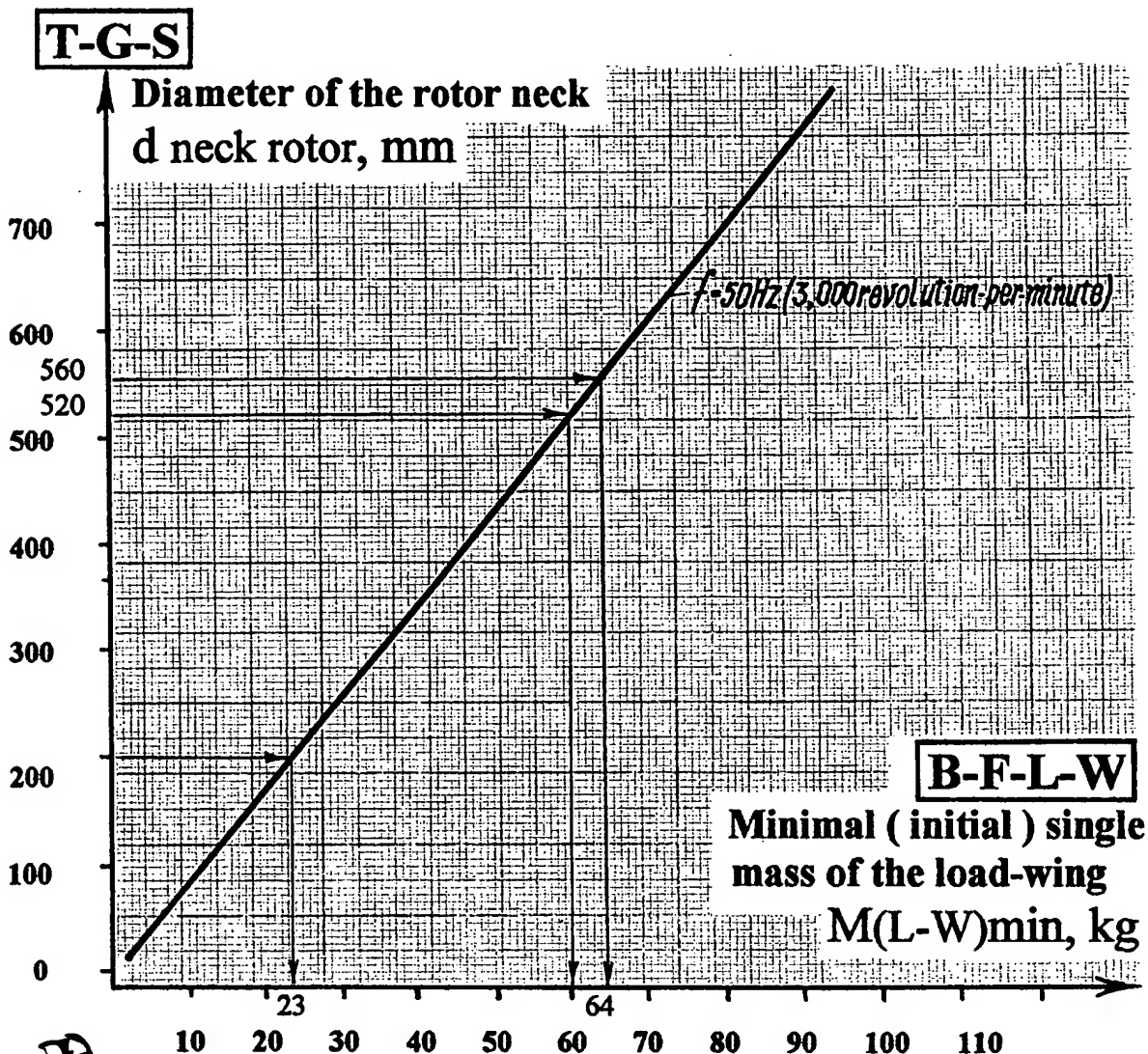
**(3 & 3') - additional variants [for loading].**

**(4 & 4') - adequate, but practically not always possible variant.**

**(5 & 5') - adequate, but practically not always possible variant.**



# **Turbine Generator Vibration Damper System. Vladilen Safonov.**

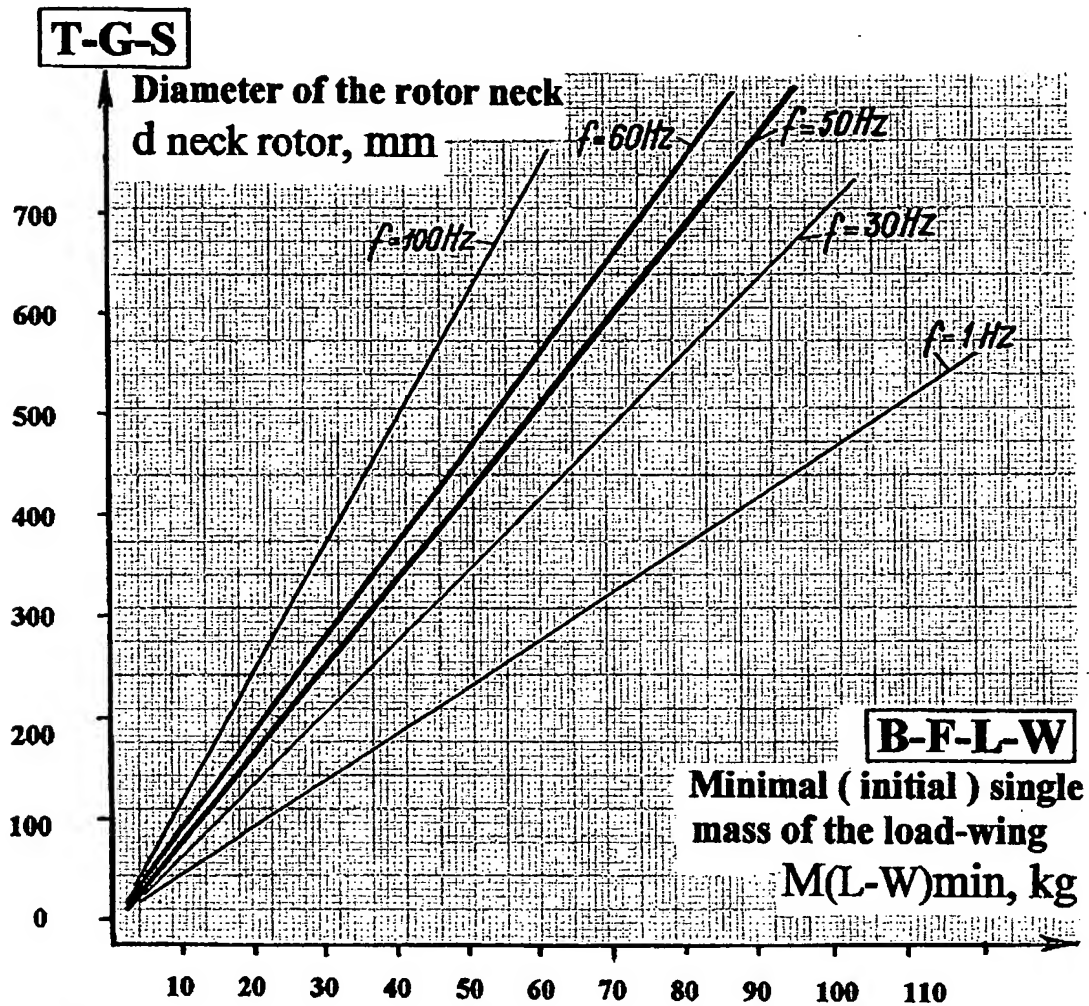


**Fig. 2** The graph for determination of initial single mass of the load-wing  $M(L-W)_{\text{min}}$  of B-F-L-W as function of diameter of the rotor neck  $d_{\text{neck rotor}}$  of T-G-S [by Vladilen Safonov].

(See text in Specification).

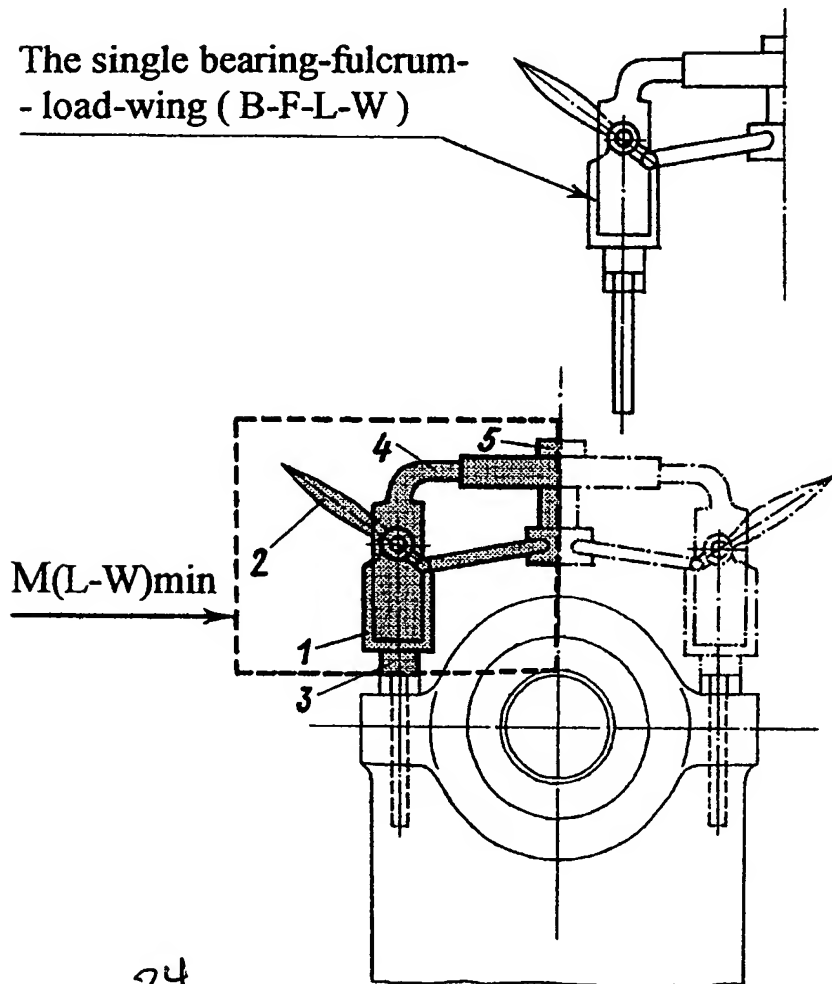
The graph may be used for determination of minimal /initial/ single mass of the load-wing: for example, for T-G-S with designed operating frequency  $f = 50 \text{ Hz}$  (3000 revolutions-per-minute), for  $d_{\text{neck rotor}} = 560 \text{ mm}$  --  $M(L-W)_{\text{min}} = 64 \text{ kg}$ ; for  $d_{\text{neck rotor}} = 520 \text{ mm}$  --  $M(L-W)_{\text{min}} = 60 \text{ kg}$ ; for  $d_{\text{neck rotor}} = 200 \text{ mm}$  --  $M(L-W)_{\text{min}} = 23 \text{ kg}$ .

# Turbine Generator Vibration Damper System. Vladilen Safonov.



<sup>13</sup>  
Fig. 6a The graphs for determination of initial single mass of the load-wing  $M(L-W)_{\min}$  as function of diameter of the rotor neck  $d_{\text{neck rotor}}$ , for various values of designed operating frequency  $f$  of T-G-Ss [by Vladilen Safonov].  
(See text in Specification).

**Turbine Generator Vibration Damper System. Vladilen Safonov.**



**Fig. 7 Distribution of the minimal /initial/ single mass of the load-wing  $M(L-W)_{min}$  among all elements and mechanisms, forming the single bearing-fulcrum-load-wing (B-F-L-W).**

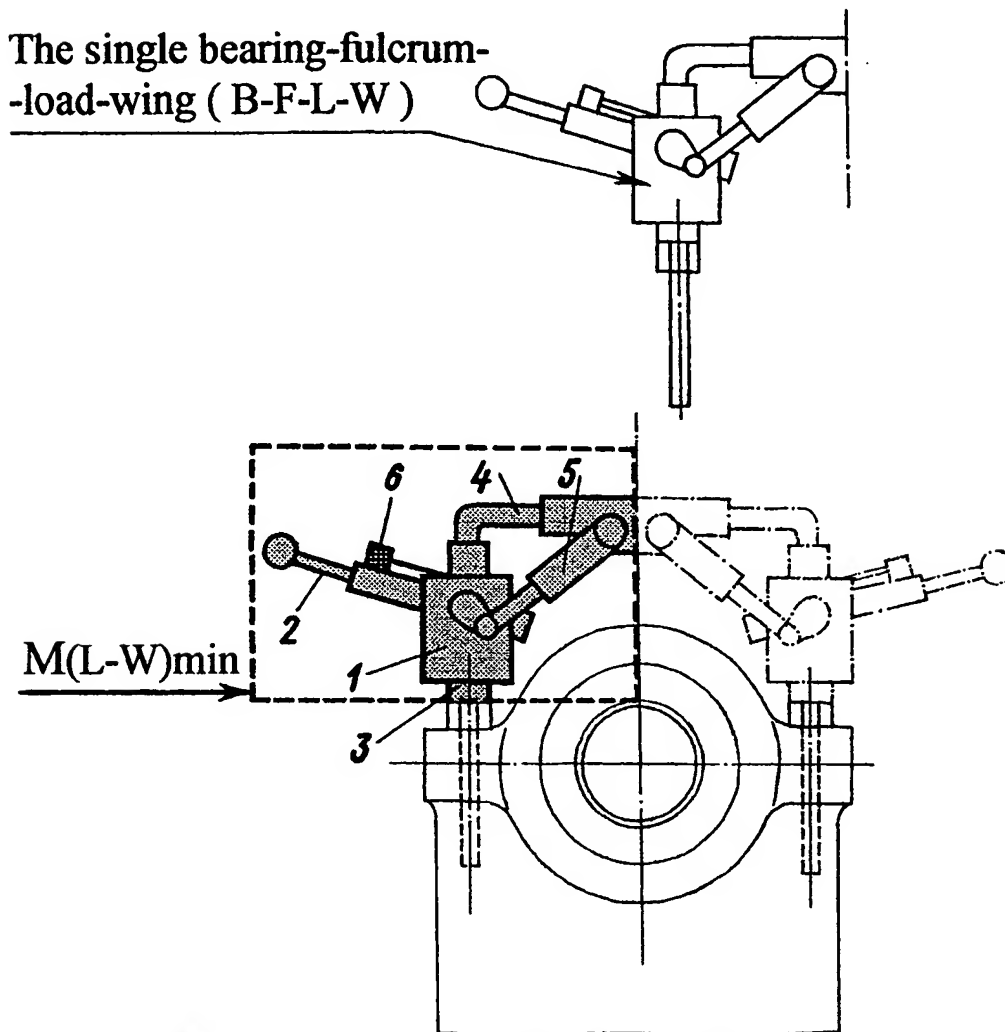
**Removal of vibrations in wide diapasons.**

**Placement of the B-F-L-Ws in direction parallelly to rotor axis.**

**A total mass of the bearing-fulcrum-loads-wings (the B-F-L-Ws) is equal to a double mass of the single bearing-fulcrum-load-wing (B-F-L-W).**

**See text in Specification.**

# **Turbine Generator Vibration Damper System. Vladilen Safonov.**



**Fig. 8 Distribution of the minimal /initial/ single mass of the load-wing  $M(L-W)_{min}$  among all elements and mechanisms, forming the single bearing-fulcrum-load-wing (B-F-L-W).**

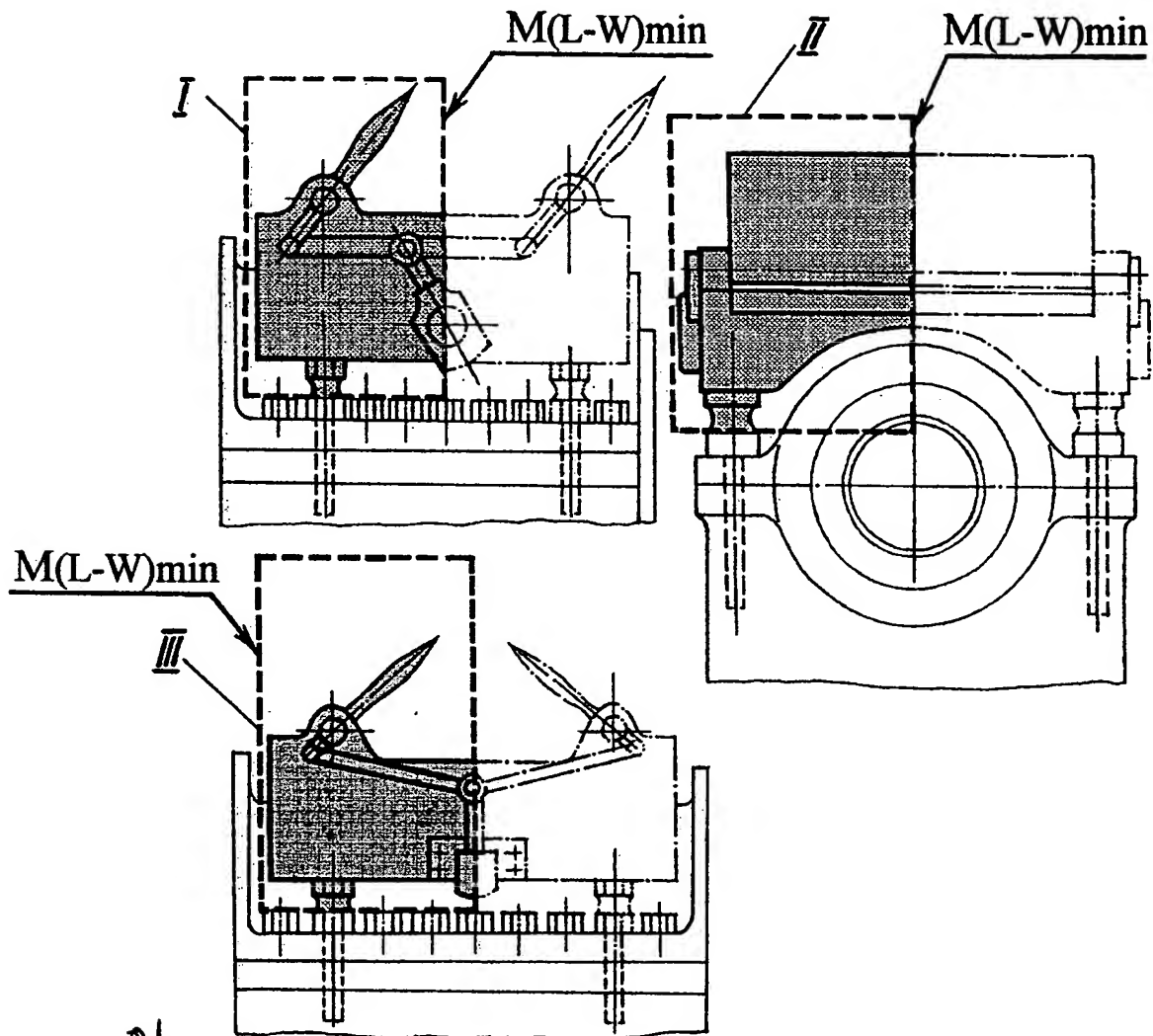
**Removal of vibrations in super-wide diapasons.**

**Placement of the B-F-L-Ws in direction parallelly to rotor axis.**

**A total mass of the bearing-fulcrum-loads-wings (the B-F-L-Ws) is equal to a double mass of the single bearing-fulcrum-load-wing (B-F-L-W).**

**See text in Specification.**

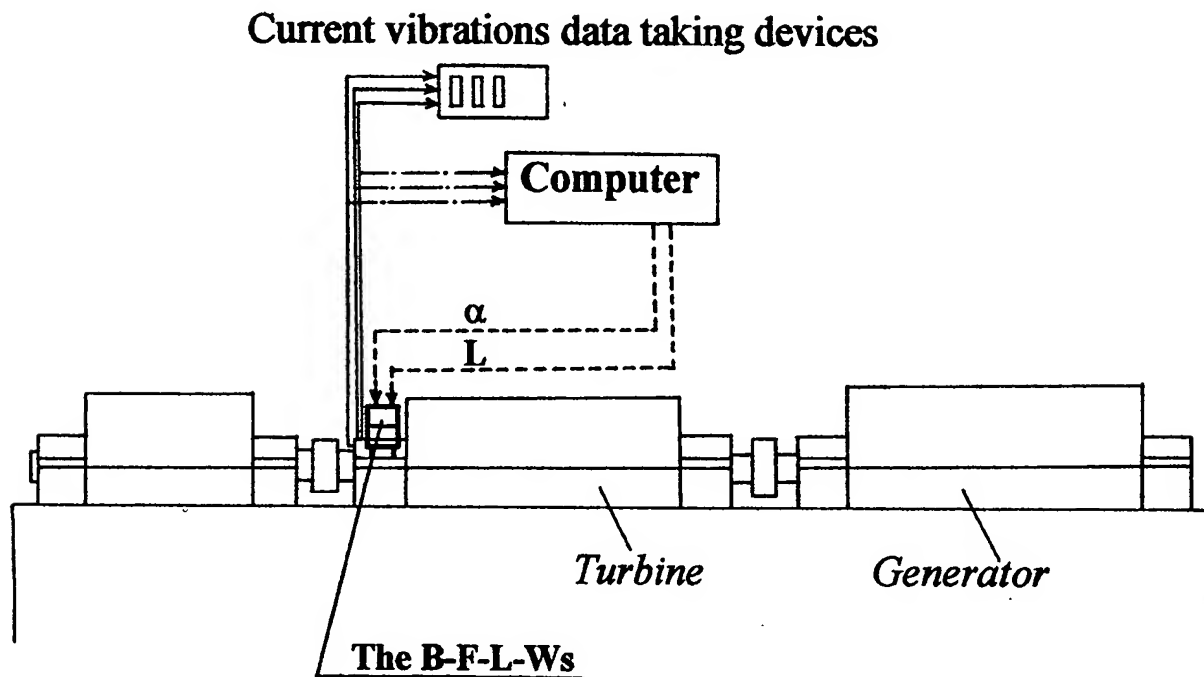
**Turbine Generator Vibration Damper System. Vladilen Safonov.**



**Fig. 26 Distribution of the minimal /initial/ single mass of the load-wing  $M(L-W)_{min}$  among all elements and mechanisms, forming the single bearing-fulcrum-load-wing (B-F-L-W).**

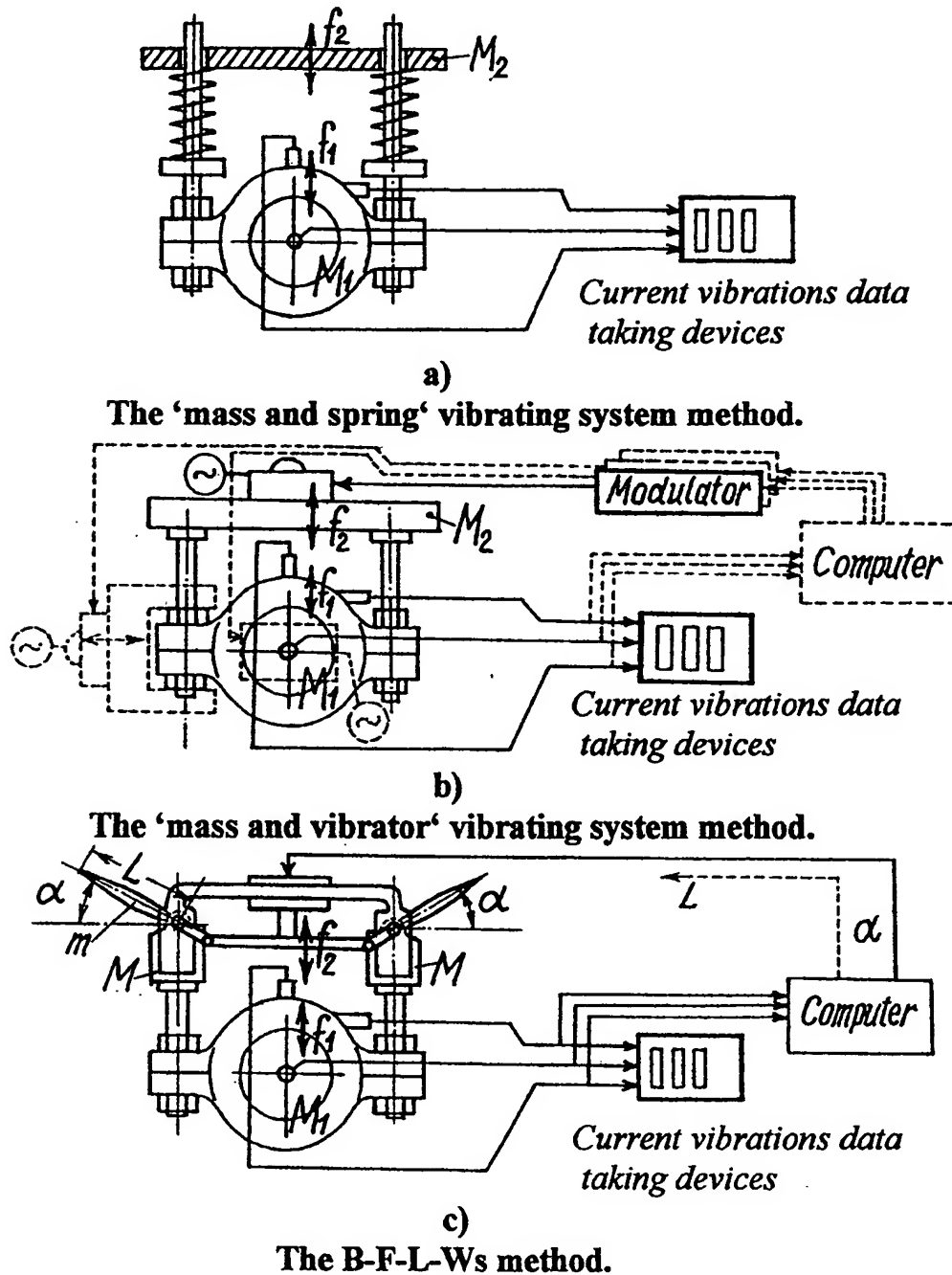
**Placement of the B-F-L-Ws in direction perpendicularly to rotor axis. See text in Specification.**

**Turbine Generator Vibration Damper System. Vladilen Safonov.**



27  
**Fig. 10 Connecting of computer with the database to the bearing vibrations indicatory system to conduct removal of beyond-normal vibrations at the bearing-fulcrum automatically.**

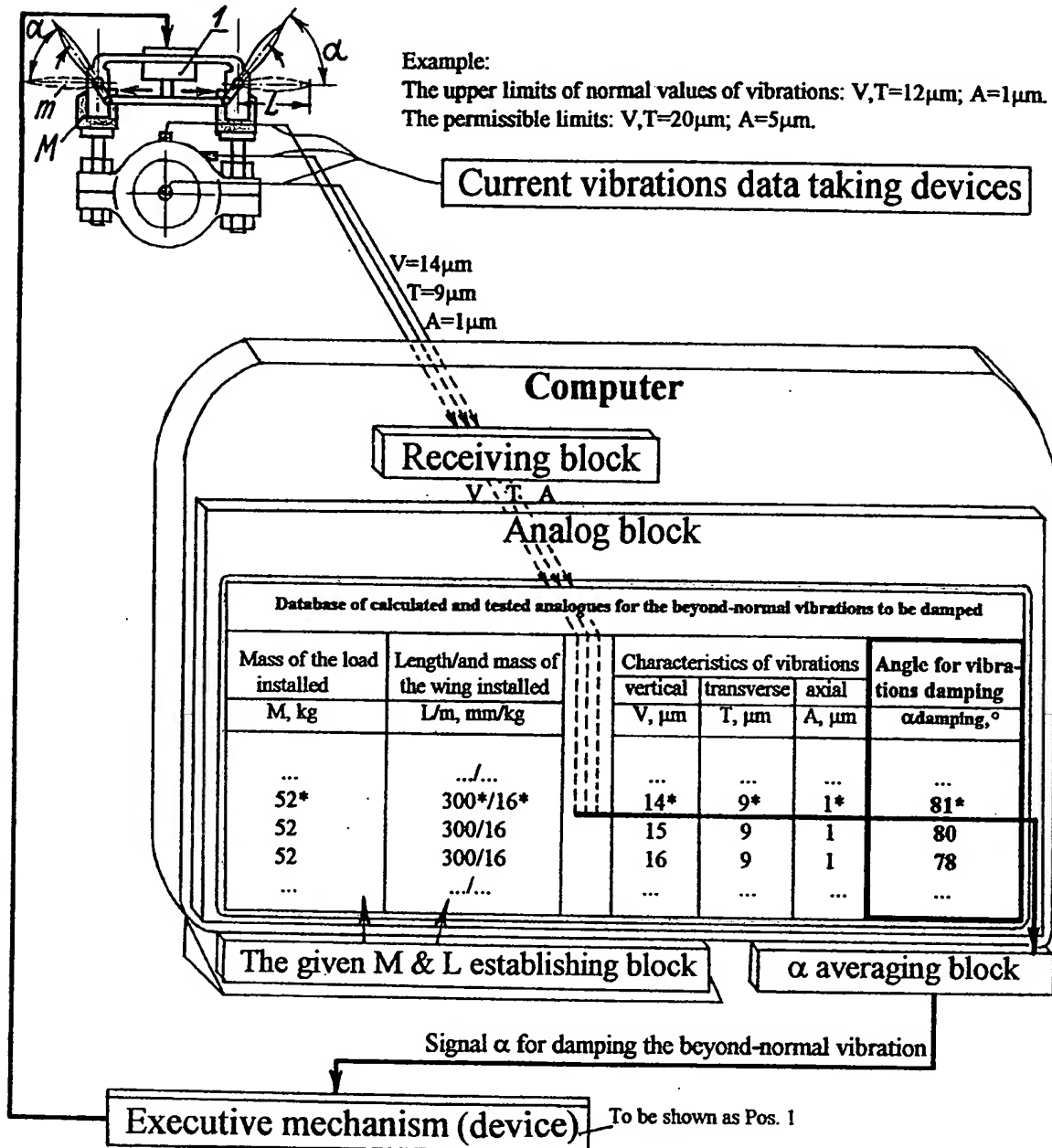
# **Turbine Generator Vibration Damper System. Vladilen Safonov.**



**Fig. 1 Other methods of damping vibration [a), b)] -- but of extremely limited capabilities to be used upon bearings-fulcra zones at T-G-Ss -- in comparison with the B-F-L-Ws method [c)].**

See text.

## Turbine Generator Vibration Damper System. Vladilen Safonov.

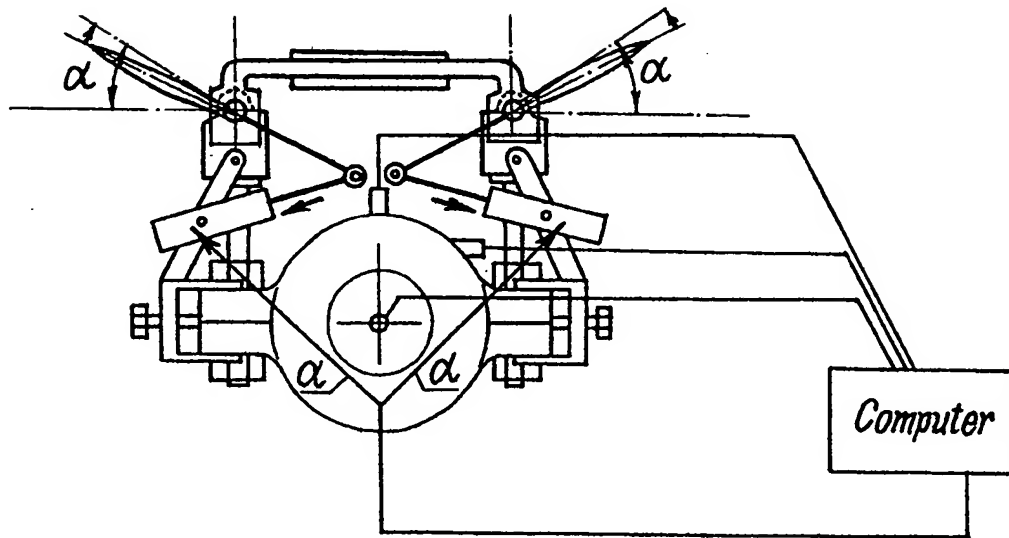


**Fig. 12 Automation - - by use a computer and automatic equipment - - of process of removal of beyond-normal vibrations at T-G-Ss. [Wide diapasons.]**

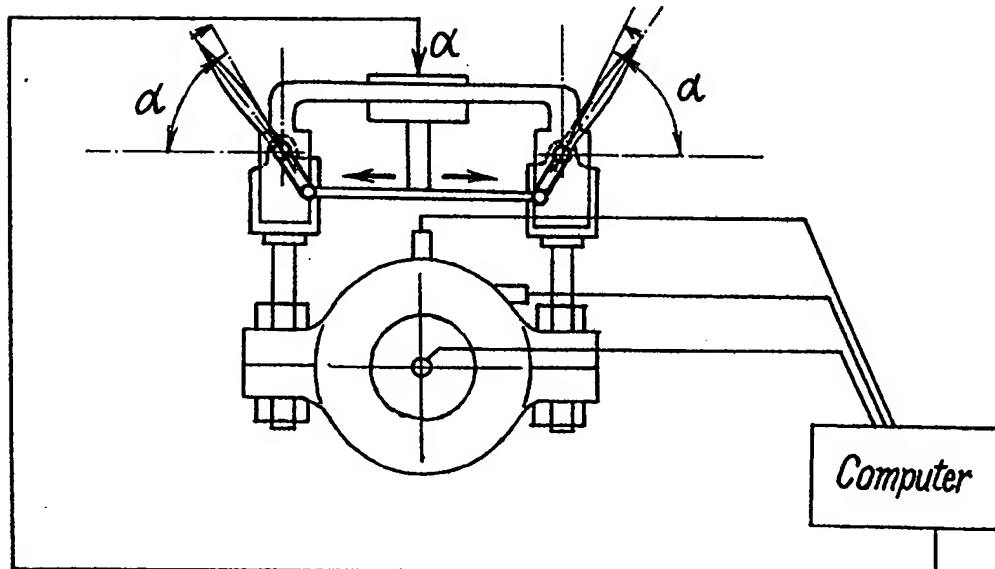
\* - Here, all the data are shown to serve as illustration only.



# **Turbine Generator Vibrati n Damper System. Vladilen Safonov.**



**Variant I. Bifurcate signal  $\alpha$ .**



**Variant II. Sole signal  $\alpha$ .**

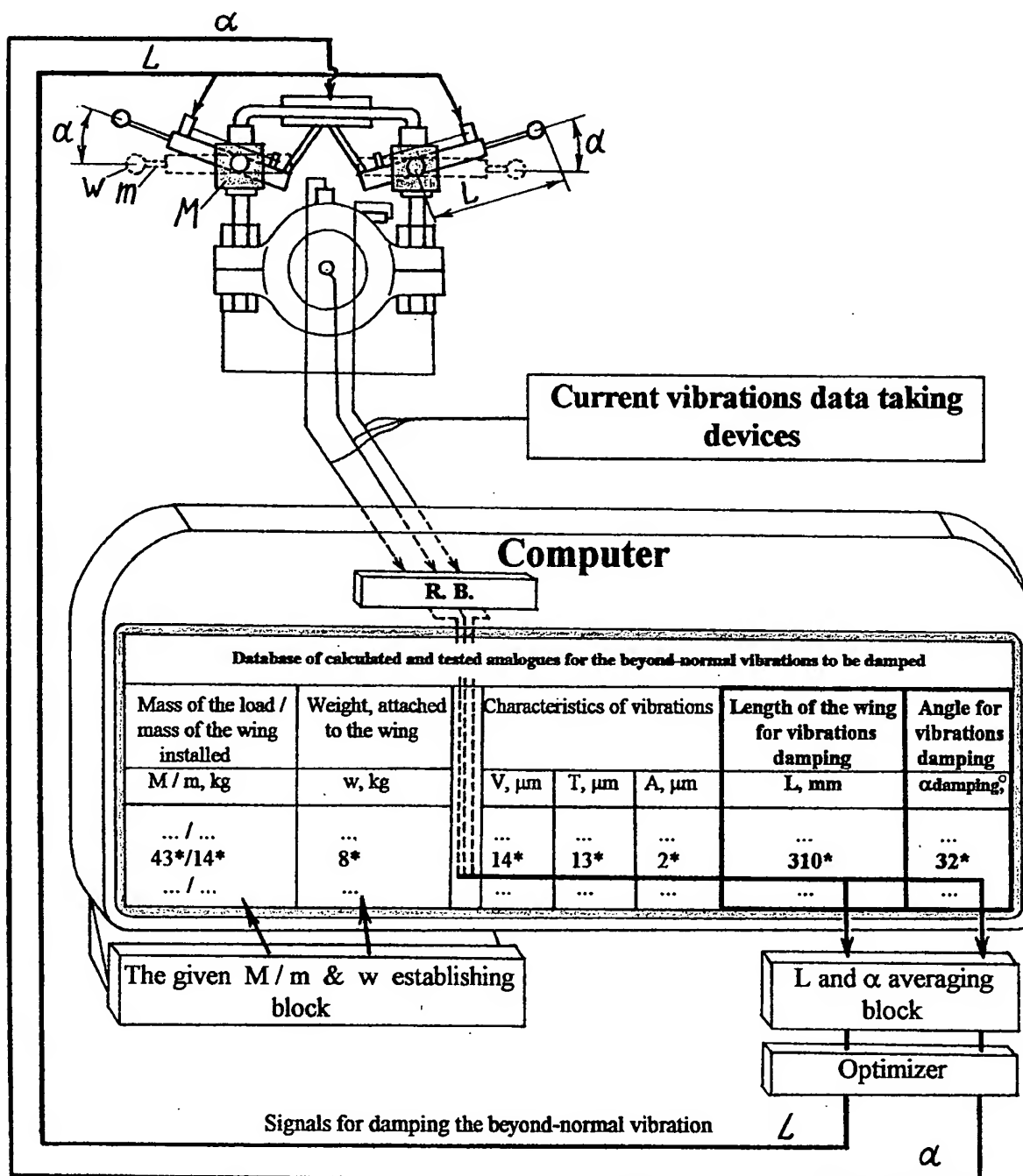
30

**Fig. 1. Variants of sending signal  $\alpha$ .**

**Variant I: Bifurcate signal sent equally to the two separate executive mechanisms for turning the wings of the B-F-L-Ws.**

**Variant II: Sole signal sent to the united executive mechanism for turning the wings of the B-F-L-Ws.**

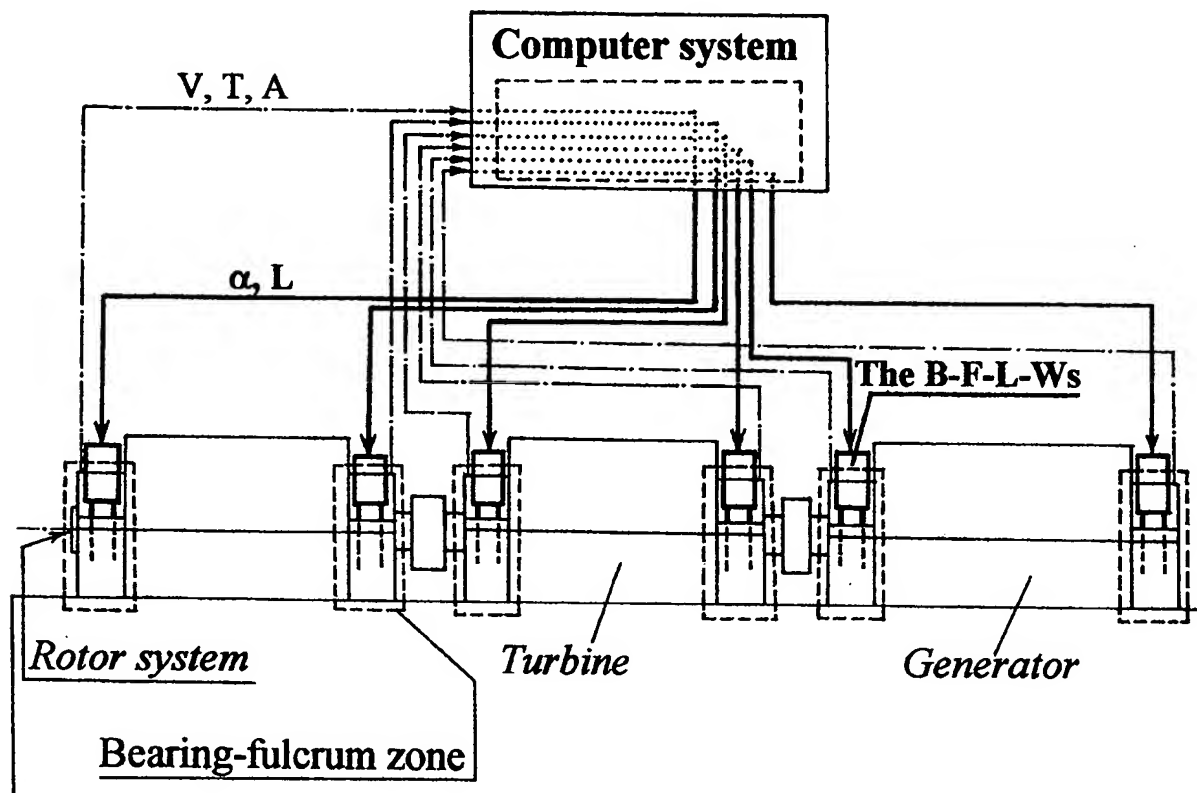
# **Turbine Generator Vibration Damper System. Vladilen Safonov.**



**Fig. 126 Automation of process of removal of beyond-normal vibrations at T-G-Ss. [Super-wide diapasons].**

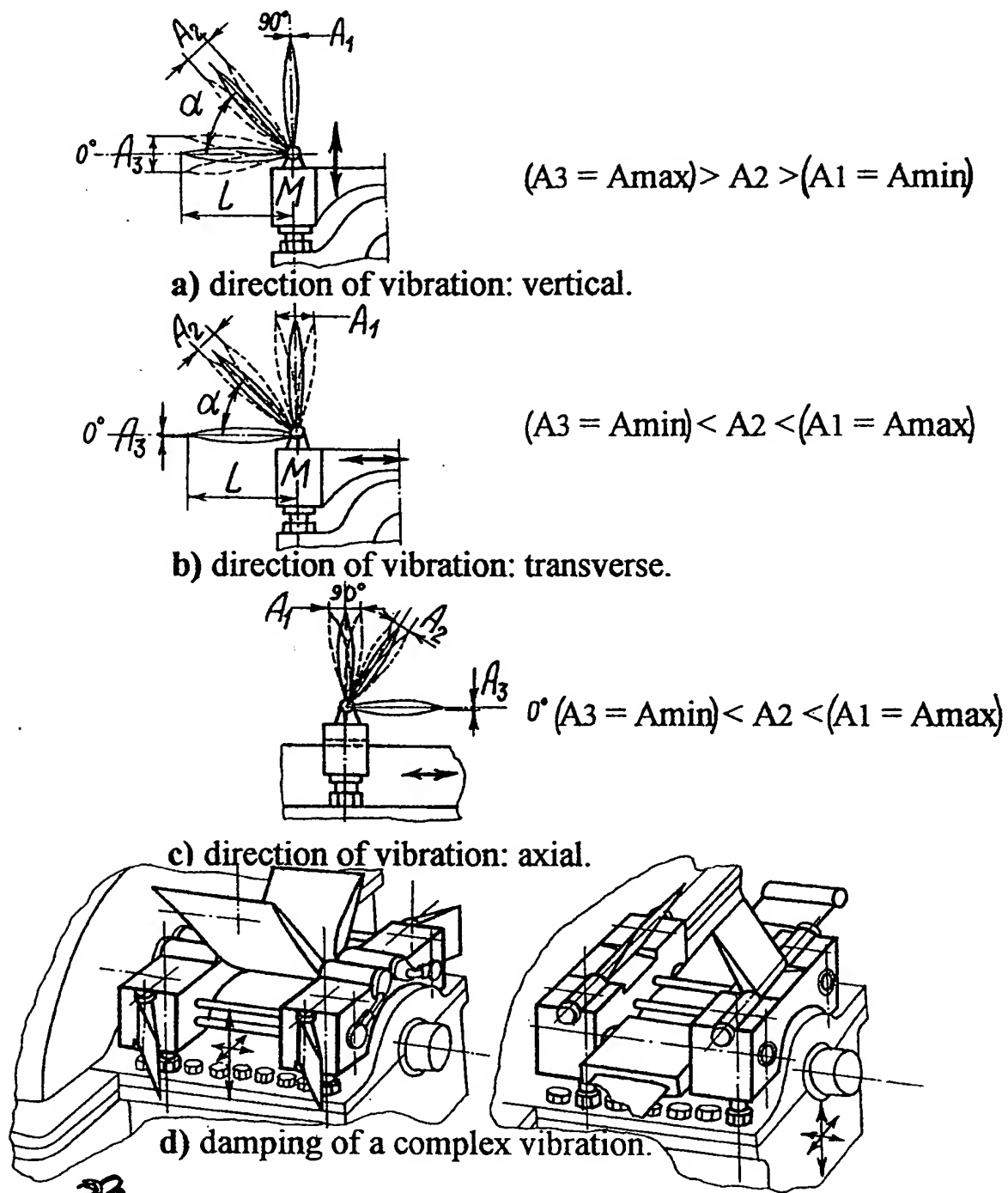
\* - Here, all the data are shown to serve as illustration only.

# **Turbine Generator Vibration Damper System. Vladilen Safonov.**



32  
**Fig. 426 Automation of process of removal of beyond-normal vibrations and keeping vibration situation normal and stable at whole T-G-S by the use of computer system and automatic equipment.**

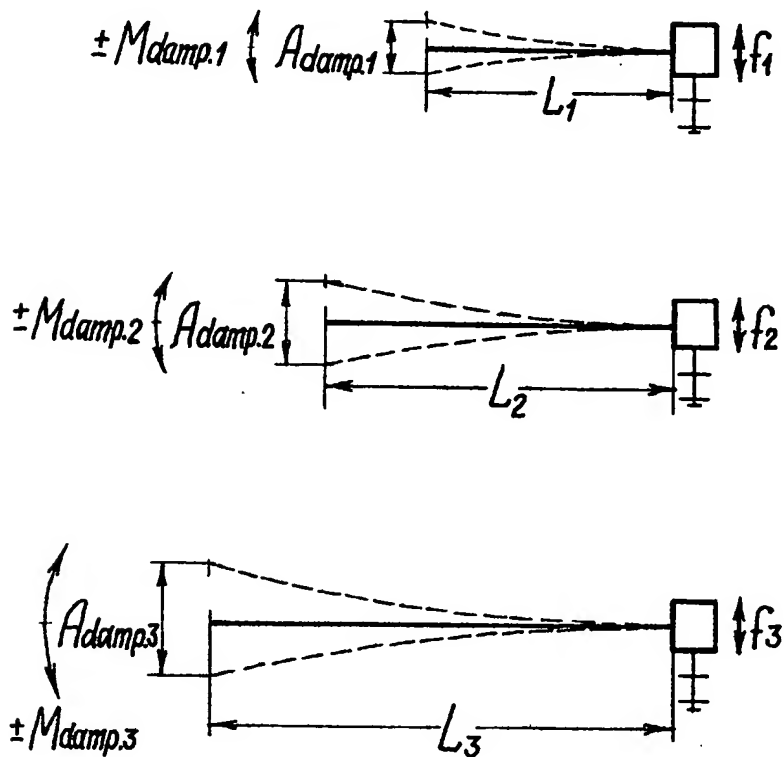
# **Turbine Generator Vibrati n Damper System. Vladilen Saf nov.**



**Fig. 33 Simple wings of the B-F-L-Ws.**

Work of simple wing for damping vertical [a)], transverse [b)], axial [c)], complex [d)] vibrations within its turn round from  $0^\circ$  to  $90^\circ$ .

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$$f_1 = f_2 = f_3 .$$

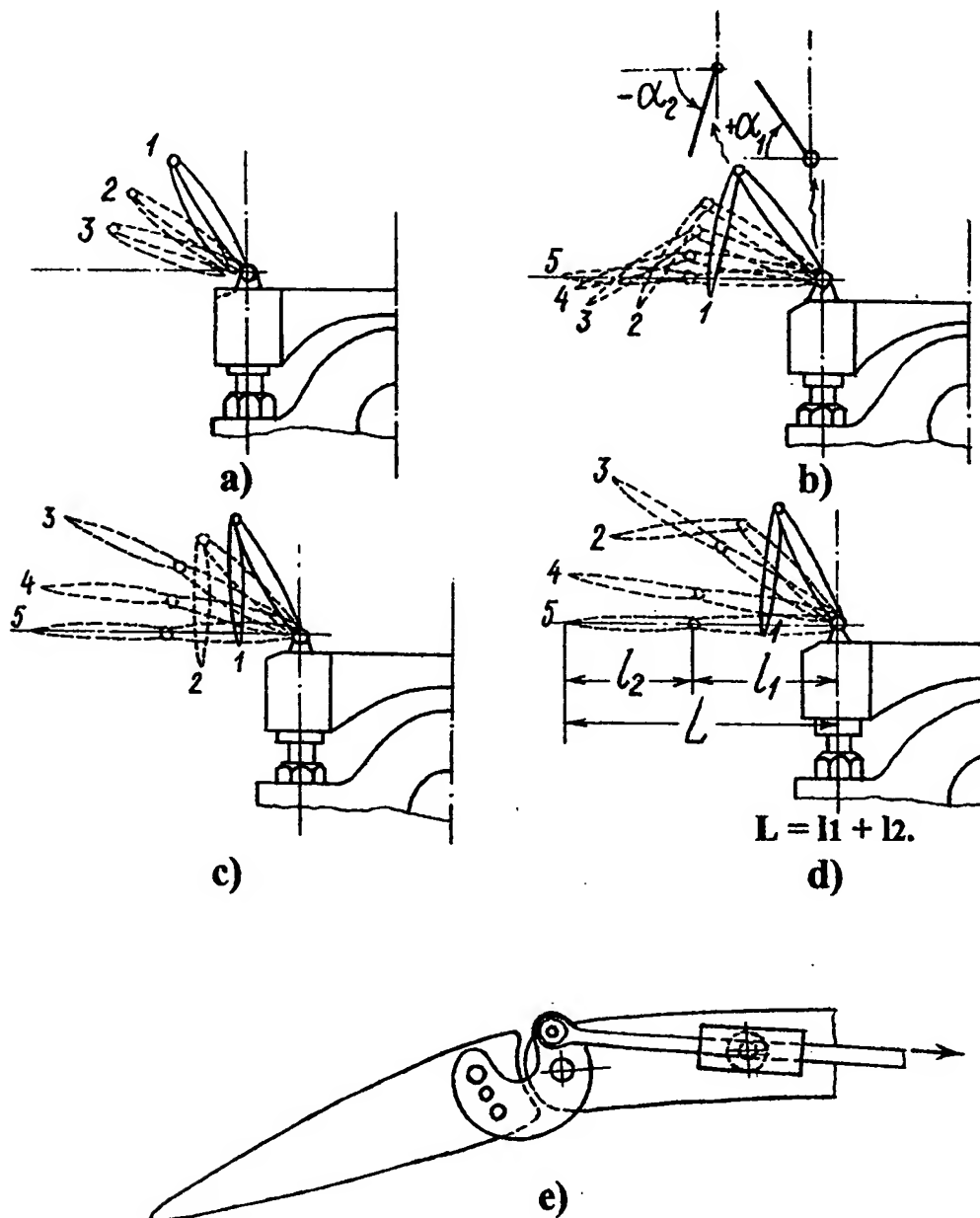
$$L_3 > L_2 > L_1 .$$

$$+ - M_{damp.3} > + - M_{damp.2} > + - M_{damp.1} .$$

$$A_{damp.3} > A_{damp.2} > A_{damp.1} .$$

34  
Fig. 34 An increase of damping capabilities (in damping momentum  $M_{damp.}$  and damping amplitude  $A_{damp.}$ ) of wing depending on elongation of its length.

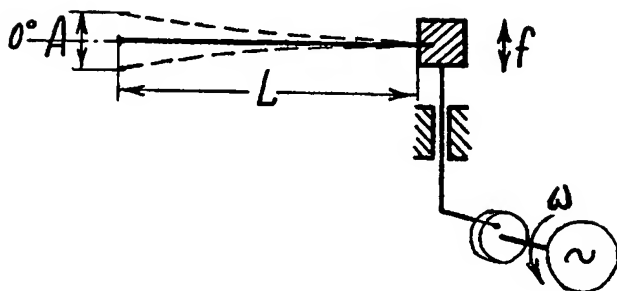
# **Turbine Generator Vibration Damper System. Vladilen Saf nov.**



35  
**Fig. 4.4a Folding wings of the B-F-L-Ws.**  
 Change of damping capabilities of folding wing depending on summary angle ( $\alpha_1 + \alpha_2 + \dots$ ) and total length of wing ( $l_1 + l_2 + \dots$ ).  
 a), b), c), d) - variants of spreading folding wings; e) - mechanism for turning the wing (variant).

## Turbine Generator Vibrati n Damper System. Vladilen Safonov.

Imitative model



Real model

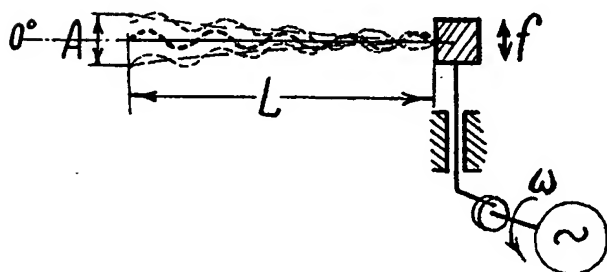


Velocity  $\omega$  is low, frequency  $f$  is low.

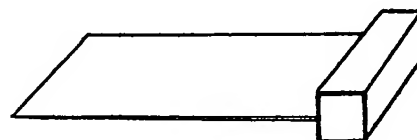
Wing is firm, non-flexible / in construction, substance or texture of material /.

a)

Imitative model



Real model



Velocity  $\omega$  is high, frequency  $f$  is high.

Wing is highly elastic, flexible / in construction, substance or texture of material /.

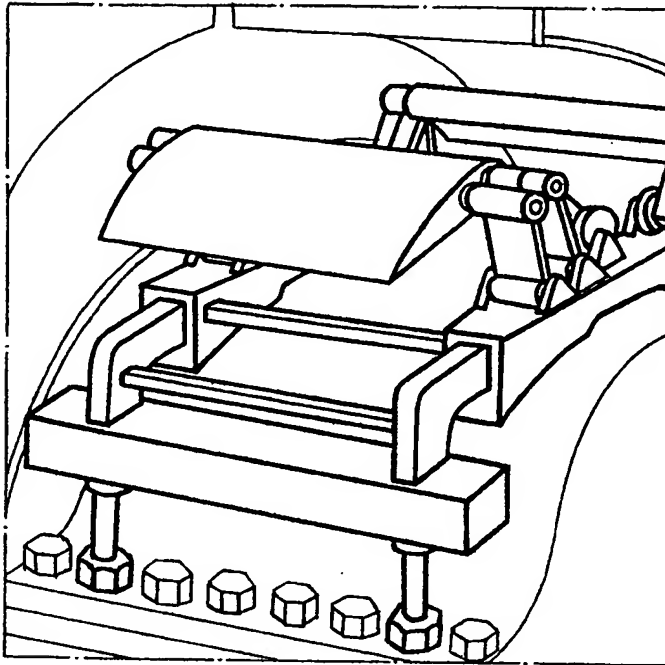
b)

36  
Fig. ~~36~~ Additional damping capabilities of wing depending on its flexibility.

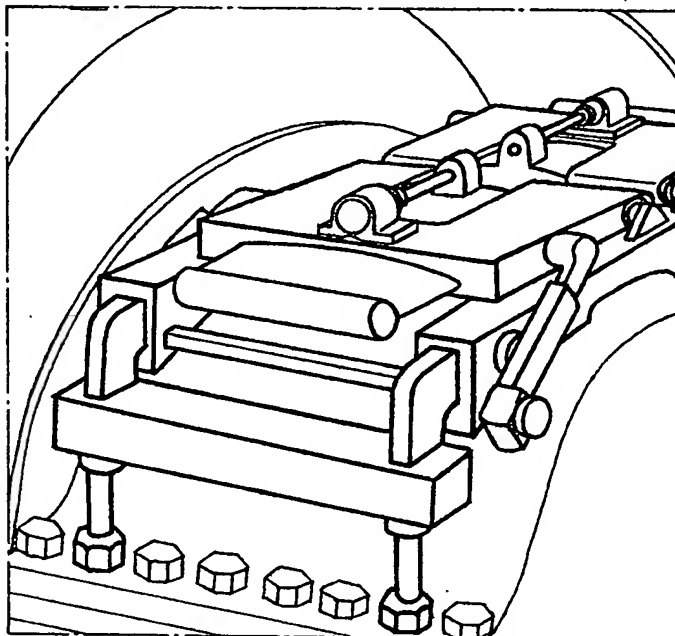
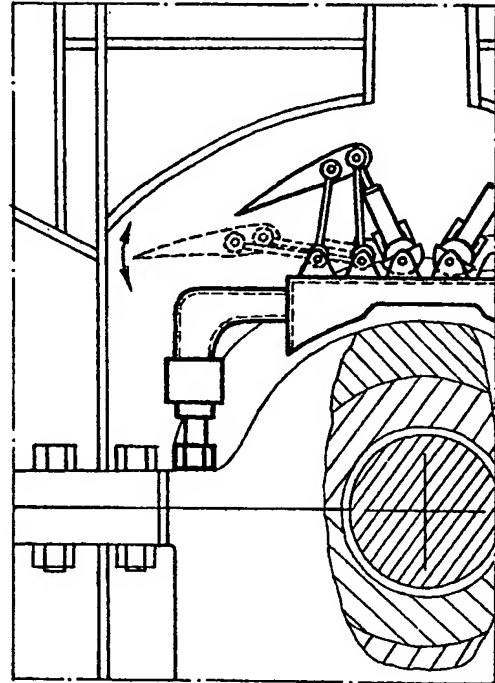
a) firm wing; b) flexible wing.

(See text in Specification).

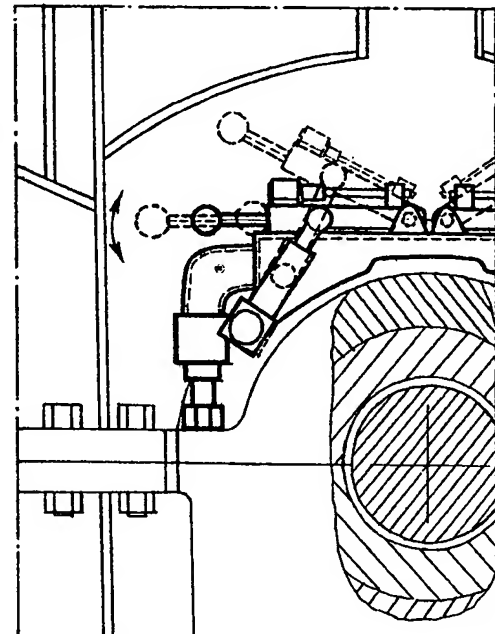
**Turbine Generator Vibration Damper System. Vladilen Safonov.**



**Variant A**



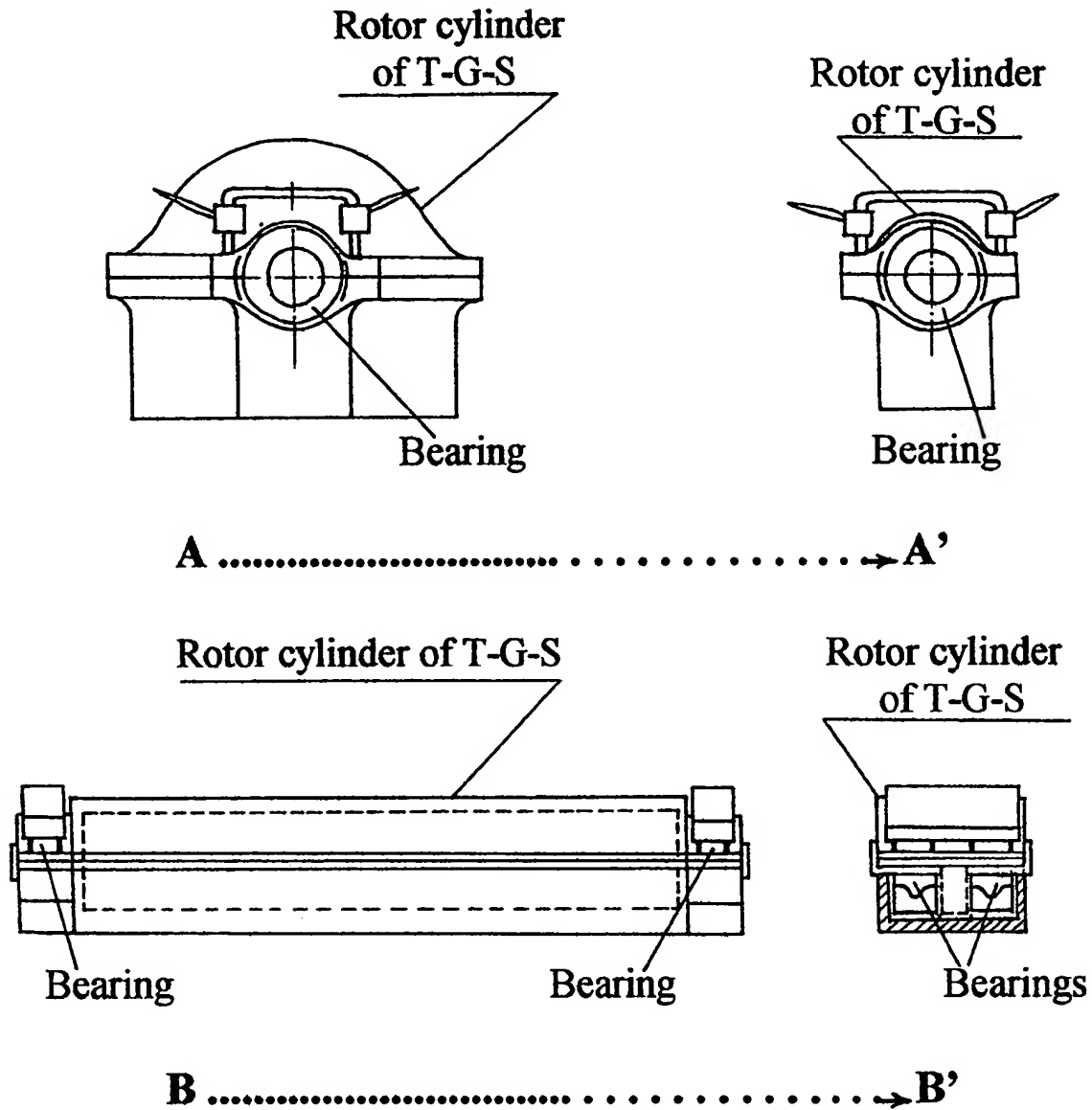
**Variant B**



**Fig. 16** Some variants of the forms of the B-F-L-Ws adapted to be used at the T-G-Ss' bearings-fulcra with limited space for spreading the wings. See text in Specification.



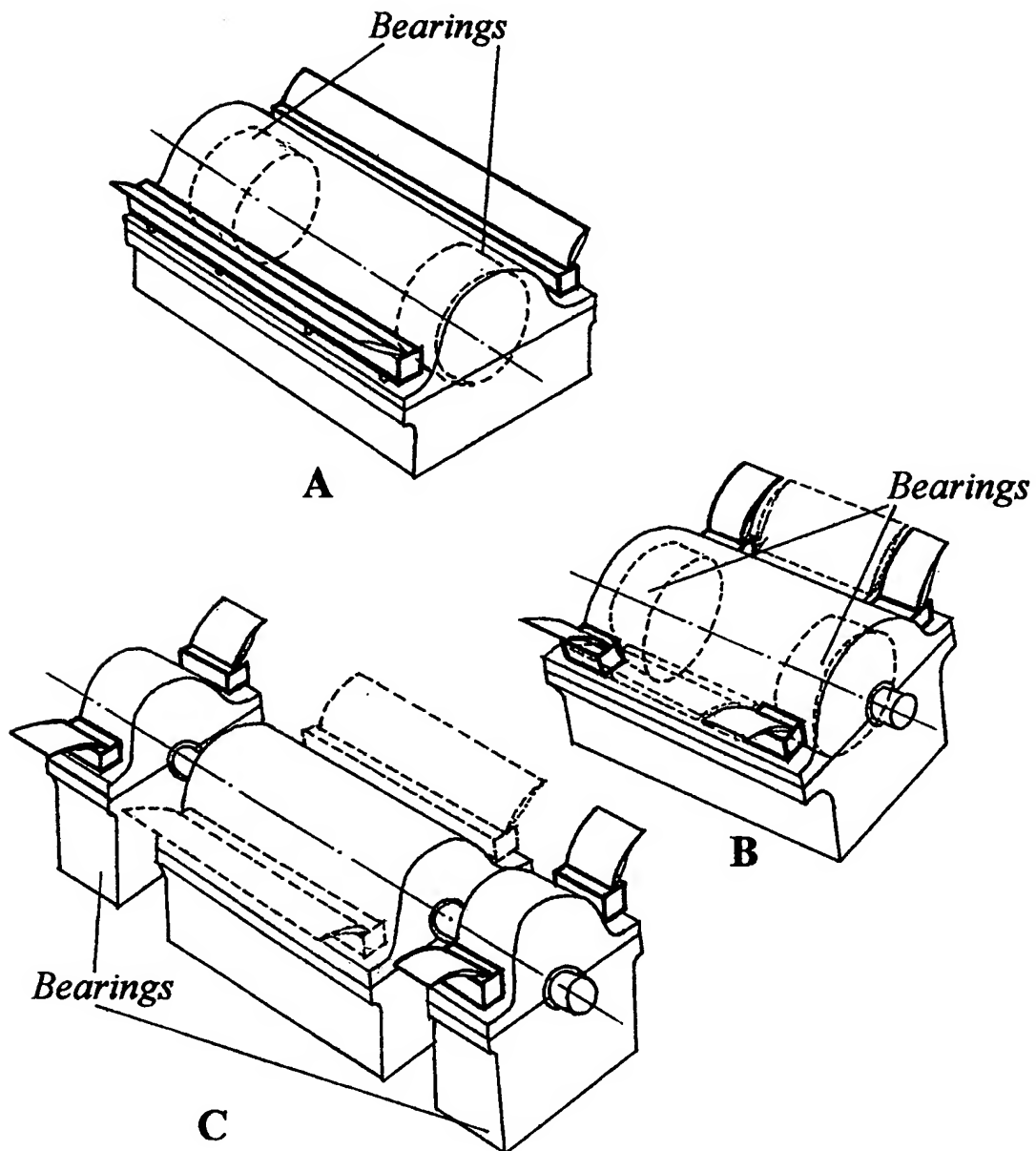
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**Fig. 147** Correlations A' and B' -- in mutual dimensions and constructions -- between bearings and their related rotor cylinder for which the method of removal of vibrations may be used so, that the B-F-L-Ws will be installed already upon whole rotor cylinder.

Those rotor cylinders are specified- see text in Specification and Limitations.

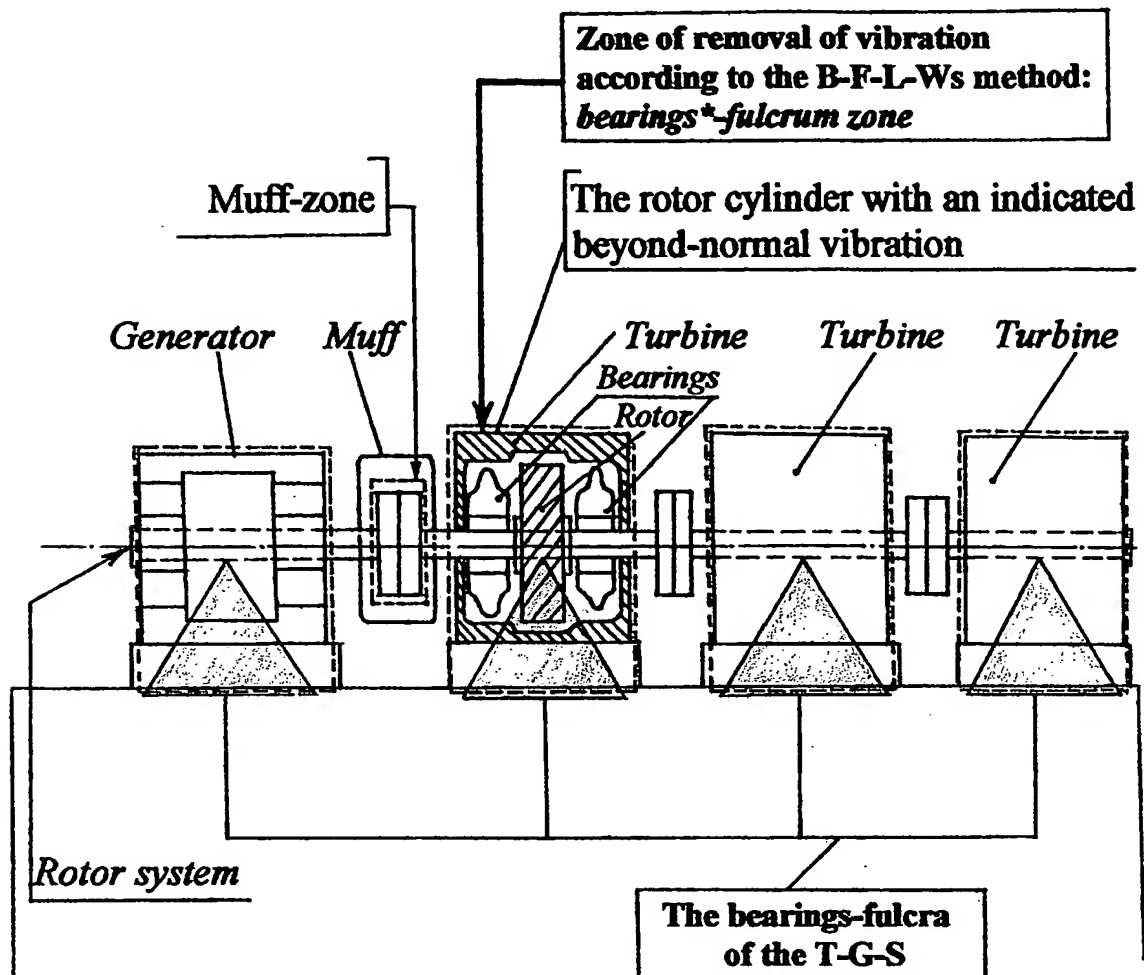
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**Fig. 18 Variants of installation of the B-F-L-Ws upon the whole rotor cylinders.**

**See text in Specification and Limitations.**

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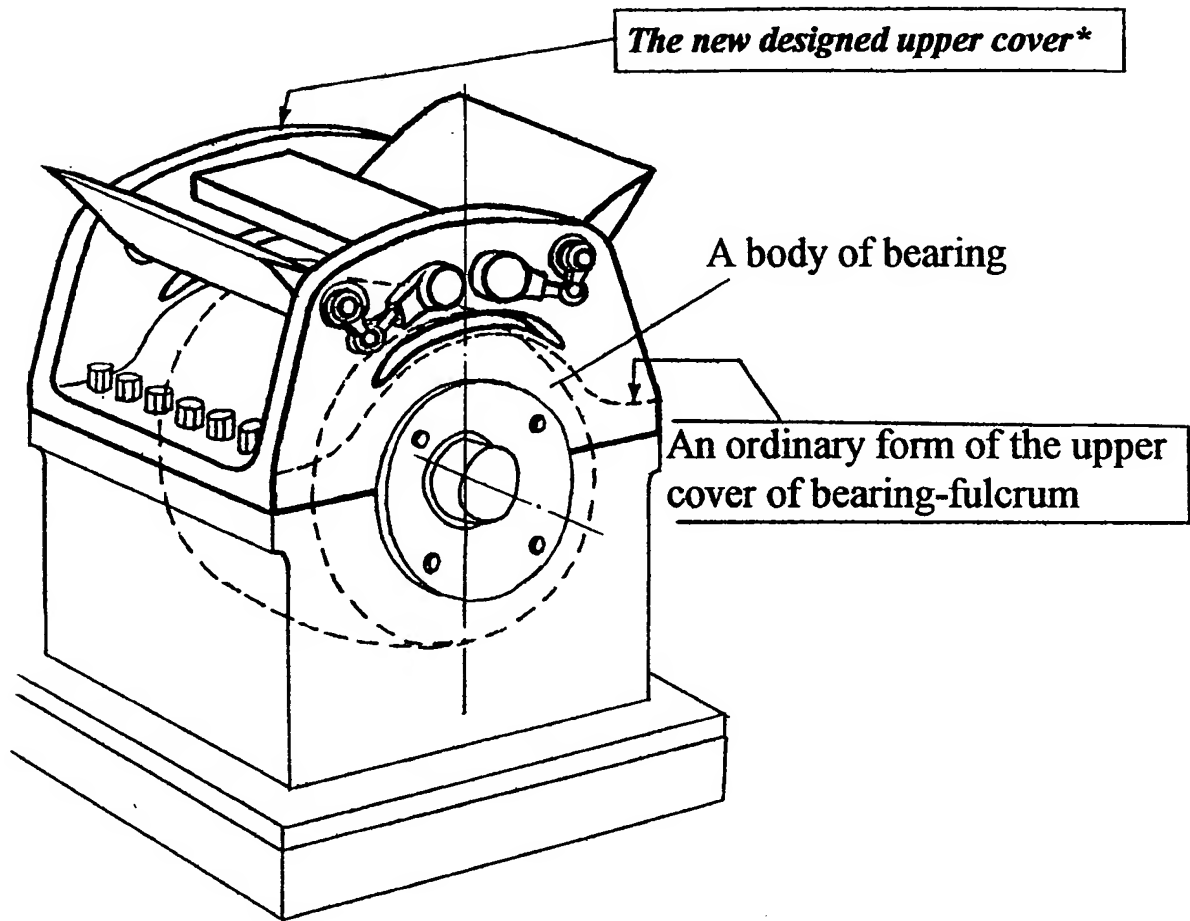
**Fig. 10 The specified rotor cylinders of the T-G-S as the fulcrum of the whole rotor system.**

When the B-F-L-Ws may be used upon whole rotor cylinder and for the corresponding specified rotor cylinders - see text in Specification and Limitations.

Installation of the B-F-L-Ws at the rotor cylinder as a whole, automation of the process of removal of vibrations at every cylinder as a whole and at whole T-G-S, the limitations are analogic to what must be done for the B-F-L-Ws to be installed and used at bearing-fulcrum.

\* - *bearings-fulcrum zone* - compare with *bearing-fulcrum zone* (see Fig. 1).

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**A**

**Bearing-fulcrum of T-G-S**

*Cont.*

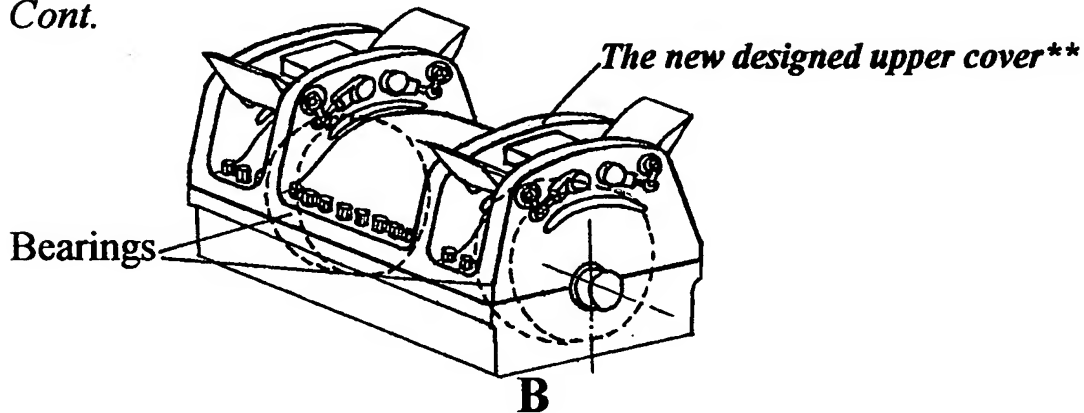
41

**Fig. 20 Variants of simple changings of the construction of bearing-fulcrum (or the form of its upper cover) in the future designed T-G-Ss to be adapted for use of the B-F-L-Ws method - removal of vibrations at T-G-Ss without stopping their generating electricity / being in operation.**

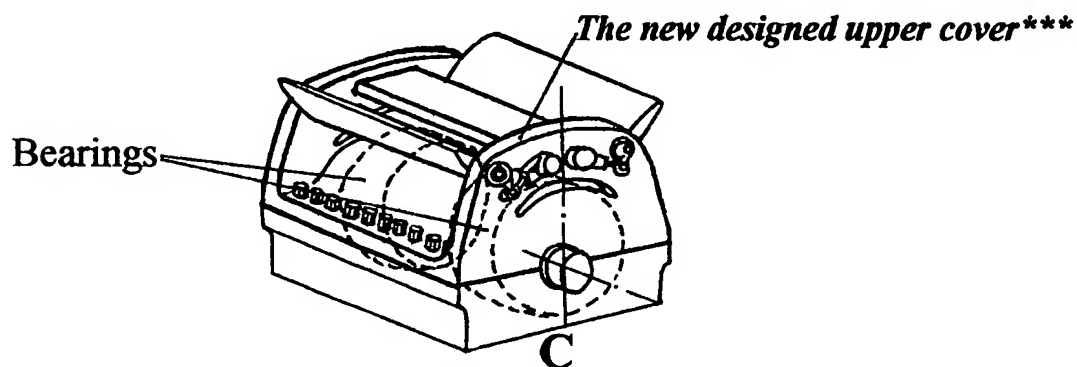
**\* - The additional mass (including loads-wings and related units) that will be added to the ordinary mass of upper cover has to be equal to a double mass of the single bearing-fulcrum-load-wing (B-F-L-W).**

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*Cont.*



**The specified rotor cylinder of T-G-S**



**The specified rotor cylinder of T-G-S**

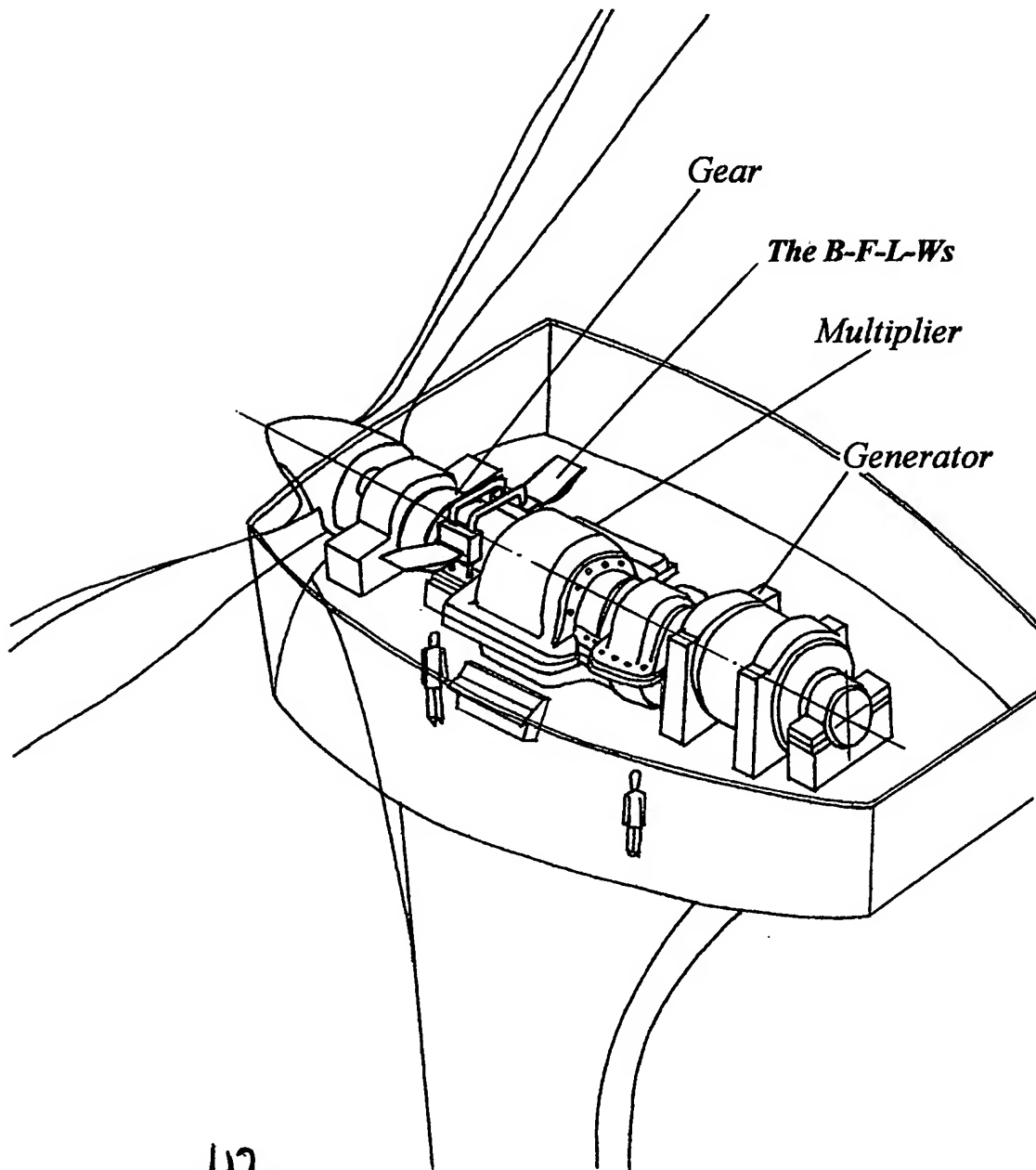
41

**Fig. 20 Continuation. Variants of simple changings of the construction of bearings-fulcrum (or the form of its upper cover) in the future designed T-G-Ss to be adapted for use of the B-F-L-Ws method - removal of vibrations without stopping their generating electricity / being in operation.**

**\*\* - The additional mass (including loads-wings and related units) that will be added to the ordinary mass of upper cover has to be equal to two double masses of the single bearing-fulcrum-load-wing (B-F-L-W).**

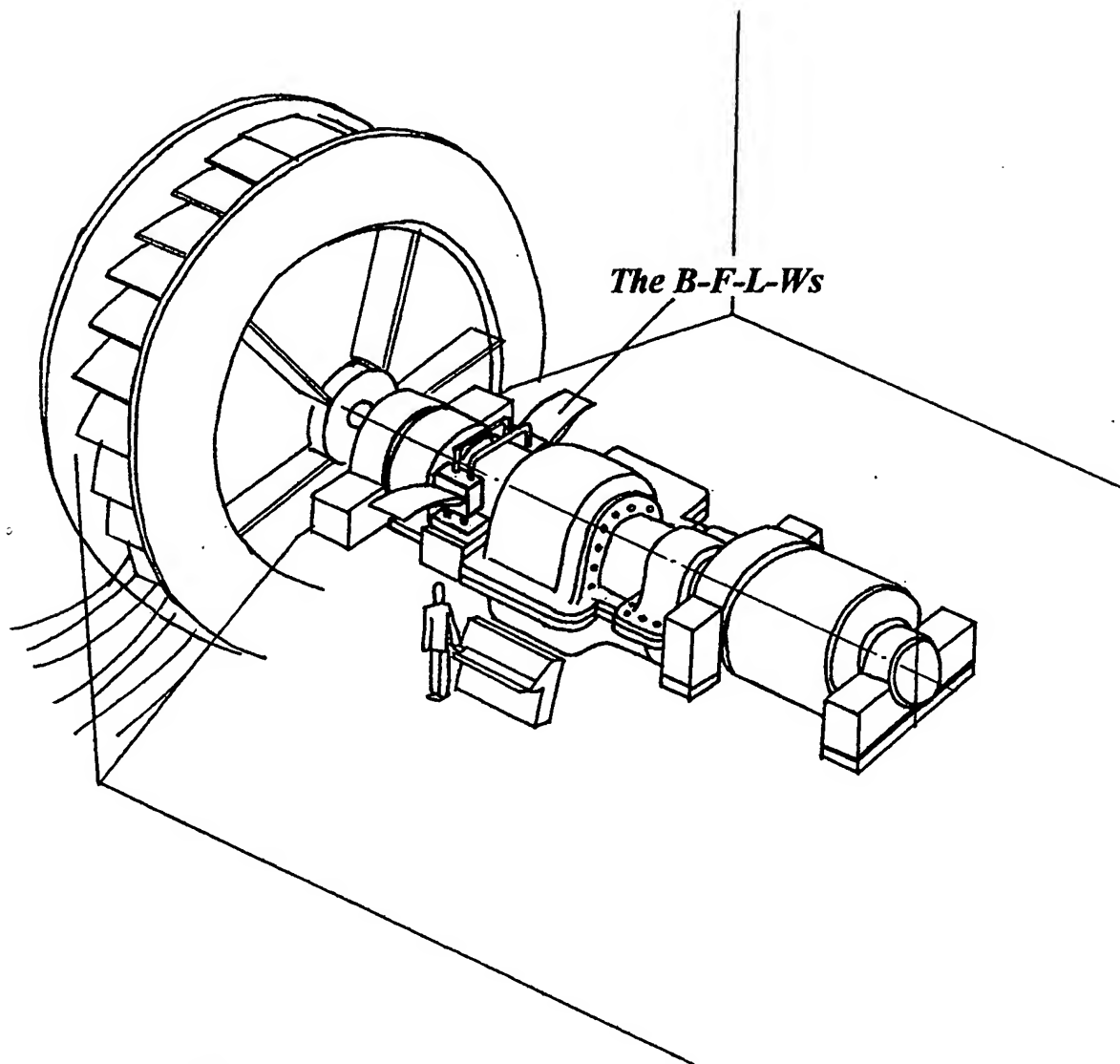
**\*\*\* - The minimal additional mass that will be added to the ordinary mass of upper cover has to be equal to two double masses of the single bearings-fulcrum-load-wing (B-F-L-W).**

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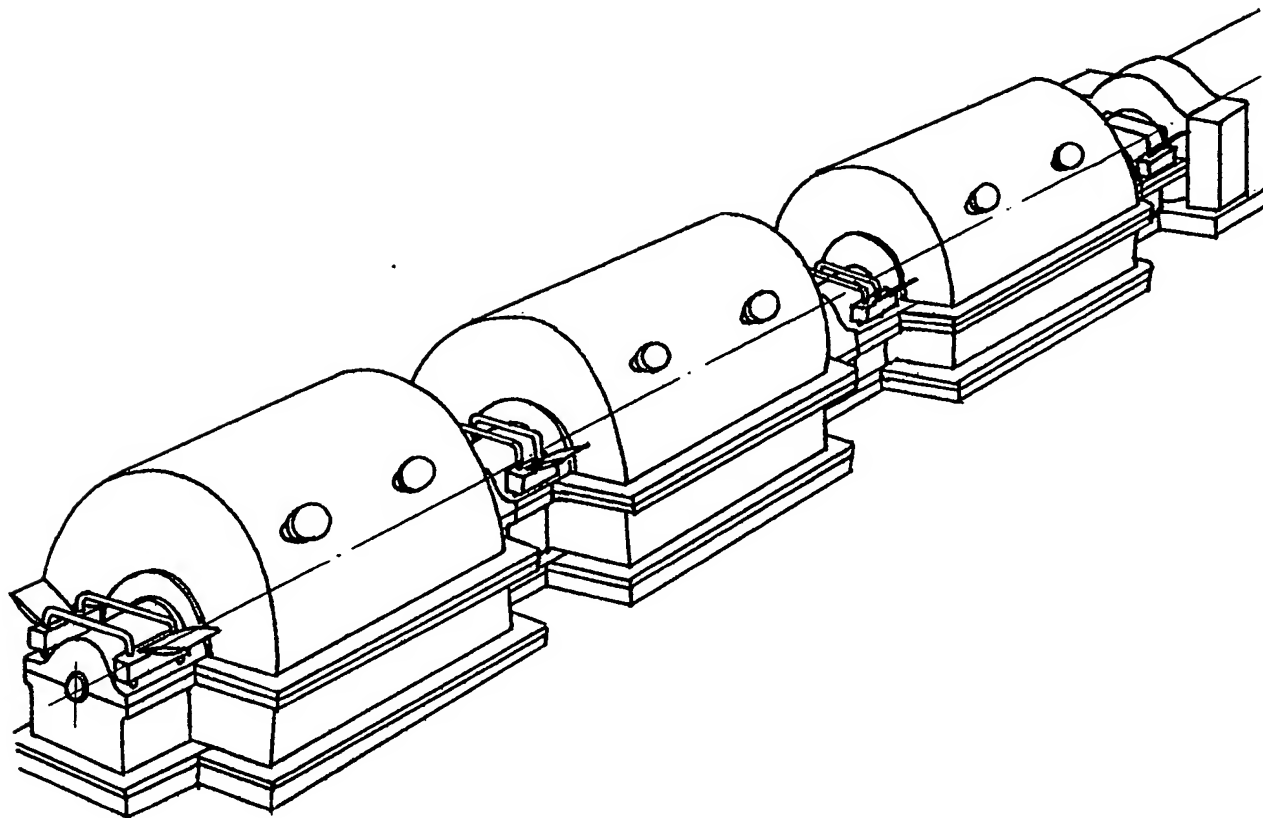
42  
**Fig. ~~41~~ Removal of vibrations with the B-F-L-Ws at bearing-fulcrum of T-G-S.**  
**Wind Electro Power Plant.**  
**General view.**

**Turbine Generator Vibration Damper System. Vladilen Safonov.**



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**Fig. 22 Removal of vibrations with the B-F-L-Ws at  
bearing-fulcrum of T-G-S.  
Hydro Electro Power Plant.  
General view.**

**Turbine Generator Vibration Damper System. Vladilen Safonov.**



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**Fig. 23 Removal of vibrations with the B-F-L-Ws at  
whole T-G-S.  
Electro Power Plant.  
General view.**